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[Concluded from Supplement No. 1639, page 26206.]

AERIAL LOCOMOTION.

WITH A FEW NOTES OF PROGRESS IN THE CONSTRUCTION OF AN AERODROME.*

By Alexander Graham Bell.

HARGRAVE BOX KITES AND TETRAHEDRAL KITES COMPARED.

Another source of danger with large continuous surfaces is the fact that a sudden squall may strike the kite on one side, lifting it up at that side and tending to upset it; but the compound tetrahedral structure is so porous that a squall passes right through and lifts the other side as well as the side first struck; so that the kite has not time to be upset before the blow on one side is counterbalanced by a blow on the other. I have flown a Hargrave box kite simultaneously with a large kite of many tetrahedral cells in squally weather for the purpose of comparing them under similar conditions. The tetrahedral structure often seemed to shiver when struck by a sudden squall, whereas the box kite seemed to be liable to a swaying or tipping motion that would be exceedingly dangerous in a structure of large size forming part of a flying-machine.

Another element of stability in the tetrahedral structure lies in the fact that the winged surfaces are elevated at a greater angle above the horizon than 45 deg.

Supposing the wings of a cell to be opened out until they are nearly flat, or at least until they each make a comparatively small angle with the horizon—say 20 deg.—then, if from any cause the cell should tip so as to elevate one wing (say to 25 deg.) and depress the other (say to 15 deg.), the lifting power of the wind will be increased upon the elevated wing and diminished on the depressed wing; so that there would be no tendency to a recovery of position, but the very reverse. The pressure of the wind would tend to increase the tipping action and favor the production of oscillation and a tendency to upset. The lifting power of the wind upon a surface inclined at 10 deg. is less than at 20 deg., and greater at 25 deg. than 20 deg. The more the wings are opened out and the flatter they become, the more essentially unstable is the arrangement in the air.

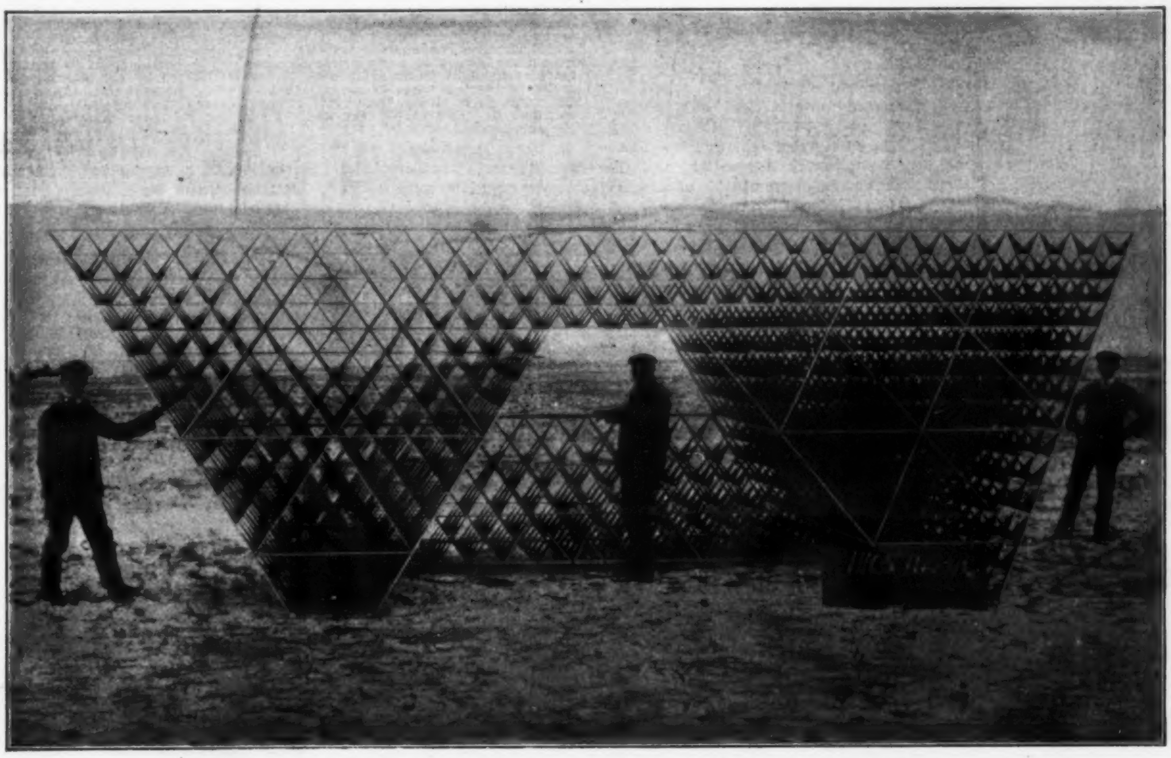
Now suppose the wings to be raised until they are nearly closed, or at all events till they make a small angle with the vertical (say 70 deg. from the horizontal), then, if from any cause the cell should tip so as to elevate one wing (say to 75 deg.) and depress the other (say to 65 deg.), the lifting power of the wind will be increased upon the depressed wing and diminished on the elevated wing; for the lifting power of the wind is greater at 65 deg. than at 70 deg. and less at 75 deg. Thus the moment a tipping action begins the pressure of the wind resists it, and an active force is invoked tending to restore the structure to its normal position. The more the wings are raised and the more they approach the perpendicular position, the more stable essentially is the arrangement in the air.

The dividing line between these two opposite conditions seems to be drawn about the angle of 45 deg. As the tetrahedral wing surfaces make a greater angle than this with the horizontal, they constitute an essentially stable arrangement in the air, whereas a horizontal surface represents the extreme of the undesirable unstable condition.

AUTOMATIC STABILITY.

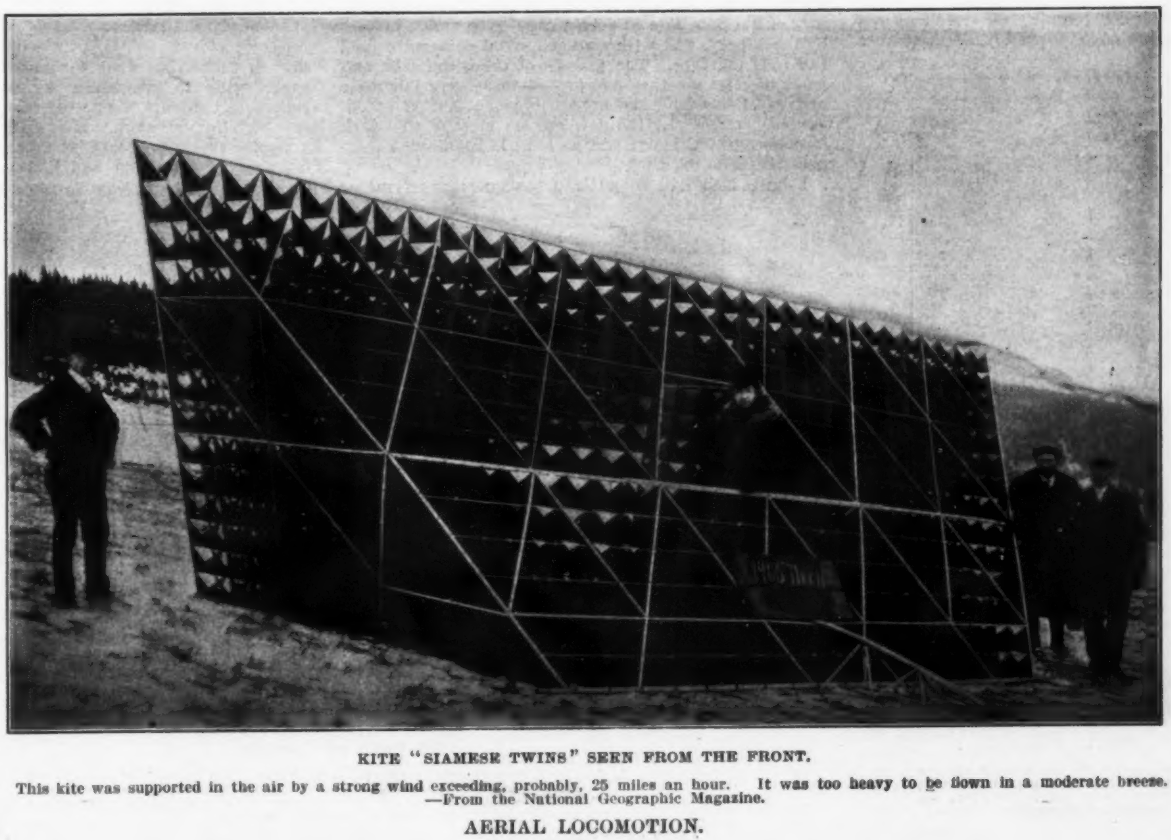
These considerations have led me to prefer a structure composed of winged tetrahedral cells alone, without horizontal surfaces either large or small,

* An address read before the Washington Academy of Sciences, December 13, 1906, and specially revised by Dr. Bell for publication in the National Geographic Magazine.



KITE "SIAMESE TWINS," SEEN FROM THE REAR, LOOKING INSIDE THE KITE.

Composed of two distinct kites connected by a bridge, or truss, of strong cells, well beaded, for the support of a man.—From the National Geographic Magazine.



KITE "SIAMESE TWINS" SEEN FROM THE FRONT.

This kite was supported in the air by a strong wind exceeding, probably, 25 miles an hour. It was too heavy to be flown in a moderate breeze. —From the National Geographic Magazine.

AERIAL LOCOMOTION.

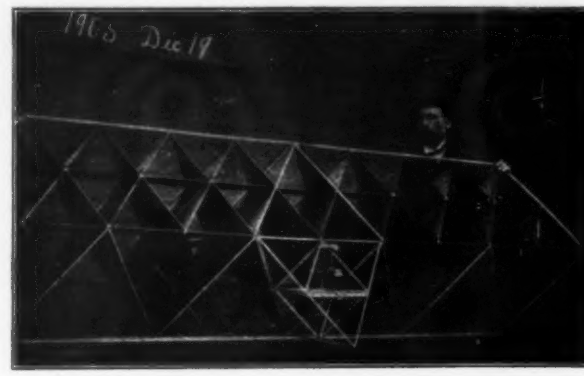
although the lifting power is less than when horizontal surfaces are employed, because the factor of safety is greater. One of the chief causes that have led to disasters in the past has been a lack of stability in the air.

1. Two 16-celled Tetrahedral Kites, the one on the right protected by a beading of wood around the outer edges. 2, 3, 4. Oionos Kite with fixed tail. 2. Front view. 3. Bottom view. 4. Top view. —From the National Geographic Magazine.

Automatic stability under varying conditions is surely of the very first consequence to safety, for what would it profit a man were he to gain the whole world and lose his own equilibrium in the air? A kite composed exclusively of multitudinous winged cells seems to possess this property of automatic stability in a very marked degree. If, then, its lifting power is sufficient for our purpose, there is no necessity for the introduction of a factor of danger by the addition of horizontal surfaces. Of course, the addition of such surfaces would enable us to secure the desired lifting power with a smaller, and therefore lighter, structure, and this would be of advantage if we could be sure of its stability in the air.

OIONOS KITE IN THE AIR.

This name was applied by the ancient Greeks to the great solitary soaring birds, from which they drew their auguries.—From the National Geographic Magazine.



OIONOS KITE WITH MOVABLE TAIL CONTROLLED BY SWINGING HEAD-LOAD OF LEAD.

When released in the air at a considerable elevation it acts very much like a soaring bird, moving forward against the wind or swinging around in large circles. It is then, in effect, a free gliding machine, which acquires considerable velocity in the horizontal direction, while descending gently in the vertical direction. The head-load gives the machine a slight tendency to dive, which is resisted by the steering action of the tail when headway is gained. The moment the head is depressed, as in diving, the weight swings forward, thus automatically causing the elevation of the tail.—From the National Geographic Magazine.

In employing tetrahedral winged cells alone upon the hollow plan of construction in which large empty spaces occurred within the kite, a practical difficulty was encountered arising from the enormous size of the structure required for the support of a man, combined with the increasing weakness of the structure as it increased in size. The discovery that the cells may be closely massed together without marked injurious effects has completely remedied this difficulty; for upon this plan not only is the structural strength improved by an increase of size, but the lifting power increases with the cube of the dimensions; so that a very slight increase in the dimensions of a large kite increases very greatly its lifting power. We now have the possibility of building structures composed exclusively of tetrahedral winged cells that will support a man and an engine in a breeze of moderate velocity without the necessity of constructing a kite of immoderate size. The experiments with the "Frost King," made in December, 1905, satisfied me upon this point, and brought to a close my experiments with kites.

CONCLUSION.

Since December, 1905, my attention has been directed to other points necessary to be considered before an aerodrome of the kite variety can be made, and to the assembling of the materials for its manufacture.

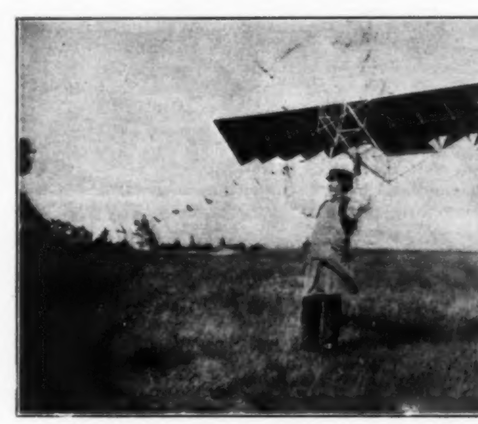
I have had to improve and simplify the method of making the winged cells themselves. Through the agency of Mr. Hector P. McNeil, superintendent of the Volta laboratory, Washington, D. C., who is now taking up the manufacture of tetrahedral cells as a new business, I am now able to obtain cells constructed largely by machinery, and with stamped metal corners to hold the rods together. The process of tying the cells and parts of cells together had proved to be very laborious and expensive, and the process was not suited to unskilled persons. By the new process most of the work is done by machinery, and no skill is required to connect the cells together.

I have also had to go into the question of motor construction—a subject with which I am not familiar—and while waiting for the completion of the material required for the aerodrome I have been carrying on experiments to test the relative efficiency of various forms of aerial propellers.

I have also been occupied with the details of construction of a supporting float adapted for propulsion over the water as a motor boat and also adapted to form the body of the flying-machine when in the air.

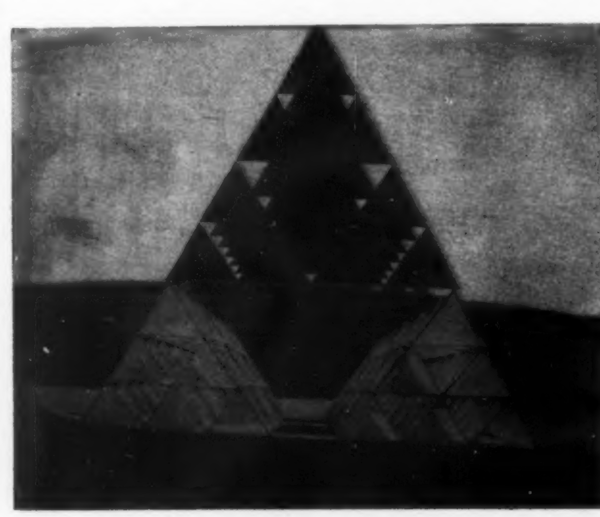
BOATS DRIVEN BY AERIAL PROPELLERS.

Of course, it would be premature for me to enter into any description of experiments that are still in progress, or to submit plans for an aerodrome which are still under discussion. I shall therefore simply say, in conclusion, that I have recently been making experiments in propelling, by means of aerial propellers, a life-raft supported, catamaran fashion, on two metallic cylinders. The whole arrangement, with a marine motor on board, is exceedingly heavy, weighing over 2,500 pounds, and it is sunk so low that the water level rises at least to the middle of the support-



METHOD OF FLYING THE OIONOS KITE.

Pieces of red silk are attached to several meters of the flying cord with the object of rendering the direction of the cord visible on the photograph plate.—From the National Geographic Magazine.



SIDE VIEW OF "MABEL II."

A floating kite supported upon three boat-like floats formed of tetrahedral cells and covered completely with oilcloth. In September, 1903, this kite was raised into the air by being towed by a steamboat against the wind.—From the National Geographic Magazine.

ing cylinders, so that the raft is not at all adapted for propulsion and cannot attain great speed. The great and unnecessary weight of this machine has led to an interesting and perhaps important discovery that might have escaped attention had the apparatus been lighter and better adapted for propulsion.

Under the action of her aerial propellers, this clumsy raft is unable to attain a higher speed than four miles an hour; and yet she is able to face a sixteen-mile white-cap breeze and make headway against it, instead of drifting backward with the wind. Under such circumstances her speed is materially reduced; but the point I would direct attention to is this: that she is not stopped by a current of air moving with very much greater velocity than her maximum possible speed in a calm. Of course, there would be nothing remarkable about this if her propellers were acting in the water instead of the air; but they were not. They acted exclusively in the air, and the water was only an additional resistance to be overcome.

"MABEL II." OUTLINED AGAINST SKY, SHOWING BIRD-WING EFFECT.

From the National Geographic Magazine.

It is worthy of note in this connection that the rapid rotation of the propellers yields a theoretical efficiency of thirty or forty miles an hour, and that the mass of the machine and the resistance of the water drag this down to an actual performance of only four miles; so that at first sight it appears probable that the effect noted may be a result of the greater slip of the propellers acting in a calm. I am inclined to think, however, that this explanation is insufficient, and would suggest the following as more probable:

The enormous mass of the moving body enables it to acquire very considerable momentum with slight velocity, whereas the opposing current of air has such slight mass that it cannot acquire an equal momentum with a very much higher velocity.

If two bodies of unequal mass, moving with equal but opposite velocities, come into collision with one another, then the heavier body will not be completely stopped by the lighter. It will make headway against the resistance of the other, even though the lighter should possess superior velocity, provided, of course, that it has a sufficient superiority of mass. We are here dealing with momentum (mv), not velocity (v) alone. The body having the greatest momentum will be the victor in the struggle, whatever the actual velocities may be.

The suggestiveness of this result lies in its application to the flying-machine problem. A balloon, on account of its slight specific gravity, must ever be at the mercy of the wind. In order to make any headway against a current of air, it must itself acquire a velocity superior to the wind that opposes it. On the other hand, it is probable that a flying-machine of the heavier-than-air type, at whatever speed it moves, will be able to make headway against a wind of much greater velocity, provided its momentum is greater than the momentum of the air that opposes it.

"THE UGLY DUCKLING."

A raft supported upon metallic cylinders and propelled by aerial propellers. The illustration shows raft propelled by small gasoline motor. In subsequent experiments referred to in the text, the bridge, or truss, supporting the propellers was raised considerably above the level of the platform, and the engine employed was a four-cylinder water-cooled marine motor weighing 650 pounds. This caused the metallic floats to be sunk to their middle points; but the floats were not connected together at their ends, as shown above.—From the National Geographic Magazine.

AERIAL LOCOMOTION.

RECENT IMPROVEMENTS IN MACHINERY FOR DRYING DIFFERENT PRODUCTS.*

By S. E. WORRELL.

NEARLY forty years ago the writer engaged extensively in the grain and meal business in Hannibal, Missouri. Much grain was shipped to southern points on the Mississippi River where the temperature was so warm and the atmosphere so humid that corn meal and new cereals frequently soured before use, because of the slight amount of moisture they contained.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

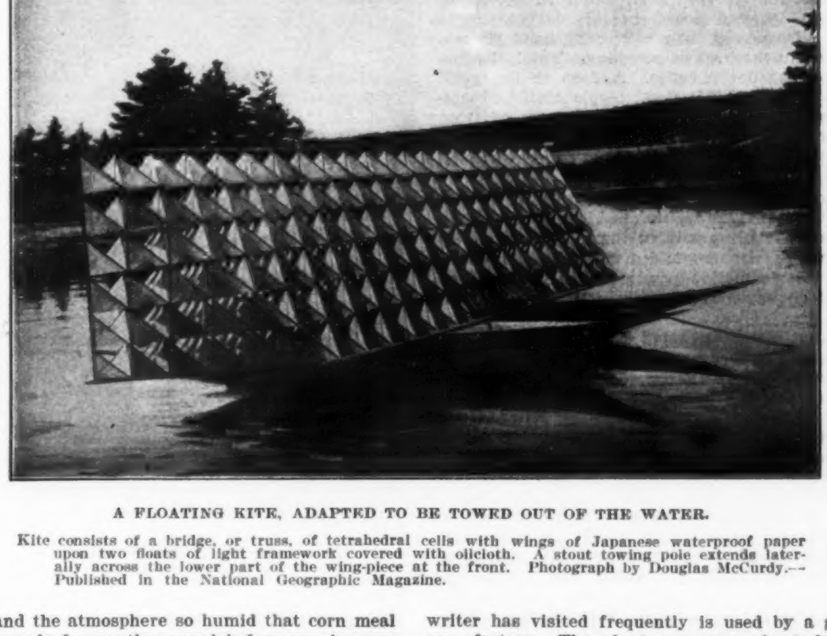
There were no drying machines or kilns then in the market. I had one constructed according to my own ideas, the machine consisting of spiral iron conveyers rotating in steam jacketed open-topped, heavy sheet-iron troughs, a cross section of which resembled the outlines of the new moon. In these kilns both grain and meal were dried with more satisfactory results. Owing to the need of higher temperatures for more rapid results and reduced floor space, some ten years later I substituted for this steam evaporator a rotating iron cylinder, filled with iron troughs, inclosed in a brick furnace heated by fire, with a rapid current of air drawn through the product by an exhausting fan.

This was much more economical and effective than my former apparatus and was the forerunner of rotary drying machines, which I have since invented.

Thirty years ago driers were employed principally for grain, fruit, sugar, and lumber. Now they are in extensive use for hundreds of widely different products and their exclusive construction has become an important industry engaging a number of plants and many skilled mechanics.

The adoption of various methods of artificial evaporation has within this time not only reduced the cost of many of our chief products, including lumber, brick, cement, wall plaster, paints, meats, cereal foods, coffee, tea, beer, whisky, and fertilizers, but also widely changed their methods of manufacture. Besides adding to the profits, they have largely benefited the sanitary conditions in the neighborhood of distilleries, breweries, starch and glucose works, meat packing plants, glue and chemical factories, the waste products of which were formerly deposited in sewers and streams that not only unfitted the water for drinking purposes but killed the fish.

Some of these drying plants are of large size, and are worth hundreds of thousands of dollars. One the writer has visited frequently is used by a great glucose factory. The plant consumes about forty thousand bushels of corn per day, occupies a massive brick building eight stories high, full of ponderous machinery of different kinds used for drying starch refuse and reducing it to bran and gluten feed, both excellent provender for stock. The process is elaborate, tests being made of the product every hour and night by expert chemists to insure its uniform strength and purity.



A FLOATING KITE, ADAPTED TO BE TOWED OUT OF THE WATER.

Kite consists of a bridge, or truss, of tetrahedral cells with wings of Japanese waterproof paper upon two floats of light framework covered with oilcloth. A stout towing pole extends laterally across the lower part of the wing-piece at the front. Photograph by Douglas McCurdy.—Published in the National Geographic Magazine.

These wet feeds, which contain the excessive amount of from sixty-eight to eighty-five per cent of water, are pumped from the main factory to the top floor of the drier building. Here the bran feed, consisting only of the skin of the corn, is run over inclined flat screens, the bottoms of which are made of a very finely perforated sheet brass through which the first water drains. It is then deposited on the wide, slowly-moving belt of the roller presses, a large machine consisting chiefly of two rollers about one foot in diameter and five feet long rotating in close proximity and faced with soft rubber some two inches thick. Between these rollers the belt carries the wet feed. A further portion of the liquid contents is squeezed out, much as if the wet material were passed through an enormous clothes wringer. These two operations have now extracted over one-half the original amount of moisture at much less expense than if an evaporating process had been used. The squeezed product is now fed continuously into one end of large drying machines, each distinguished by a long, round, double-jacketed cylinder of boiler plate filled with either exhaust steam or live steam at a pressure of about one hundred pounds to the square inch. The use of live steam greatly increases the drying capacity of the evaporator, because the temperature is nearly one hundred degrees Fahrenheit higher than that of exhaust steam.

In the interior of this jacket is a long rotating agitator which spreads and throws the product in showers presenting it in the most advantageous condition to the action of the rapidly-moving hot air currents, forced through the machine by an exhausting fan. The moisture is quickly removed from the feed and removed in the form of vapor. The machine is slightly inclined so that the product gradually moves to the opposite or lower end, from which it is discharged thoroughly dried, ready for bagging or shipping.

The wet gluten feed, consisting principally of the heart of corn, owing to its fine condition, much resembling cream, requires a different preliminary treatment. It is pumped into powerful filter presses, similar to those used in sugar mills, under a pressure of one hundred and twenty-five pounds to the square inch which forces out about two-thirds of the water. It then enters the drying machines from which it is discharged in different degrees of fineness from that of dust up to the size of marbles so that it must be ground and screened before shipment.

Besides the apparatus described the establishment in question contains numerous bucket elevators, spiral iron conveyers, bag packers, and extensive motive connections.

Distillery slop and brewers' wet grain require very similar treatment to that just described.

Meat packers have found the drying machine a boon. Their tankage, consisting of the refuse of lard and tallow rendering tanks and of blood (waste which they formerly paid to get rid of) are now bringing large sums of money for fertilizers.

The treatment of blood is interesting. It is collected in iron tanks, coagulated by heat, and then subjected to heavy pressure to squeeze out the fats and most of the water. The fats are separated from the water by gravity. The solid matter after drying forms a valuable fertilizer. The utilization of the products formerly wasted has closed hundreds of small meat packing plants throughout the United States who could not afford to put in the expensive machinery necessary for using their offal.

Another comparatively recent demand for drying machines has come from large coffee planters who formerly spread their ripe berries out in *patios* on hard or baked ground floors, in thin layers. The berries were frequently turned over by hand shovels and subjected to the heat of sunshine. Tropical rains sometimes damaged the coffee. A drop in the price of common grades of this great staple at the plantations during the past quarter of a century of from about ten cents per pound to half that amount has forced the planter to abandon his old expensive hand labor and to adopt elaborate and costly machinery to reduce his operating expenses and improve the quality of his product. Besides drying machines an up-to-date coffee mill now requires pulpers, fomenting tanks, centrifugals, hullers, cleaners, and graders, besides water, steam, or electric motive power, under the superintendence of an expensive American or European expert.

For the past few years some enterprising inventors have been quietly endeavoring to dry cheese curd into a white powder, a very difficult task, because the curd contains an excessive percentage of acidulous liquid which cannot be drained or pressed out without materially reducing the strength of the product. At a very moderate evaporating temperature the curd melts into a glutinous mass which cannot be pulverized, and the acid content volatilizes.

Drying machines and evaporators find novel use in desiccating sweet potatoes and other vegetables, mahogany bark, match sticks, stable manure, natural soda, sea grass, sponges, and sumac leaves. Banana flour, thus reduced from raw bananas, has excellent prospects. A machine for drying bananas has a great commercial future before it.

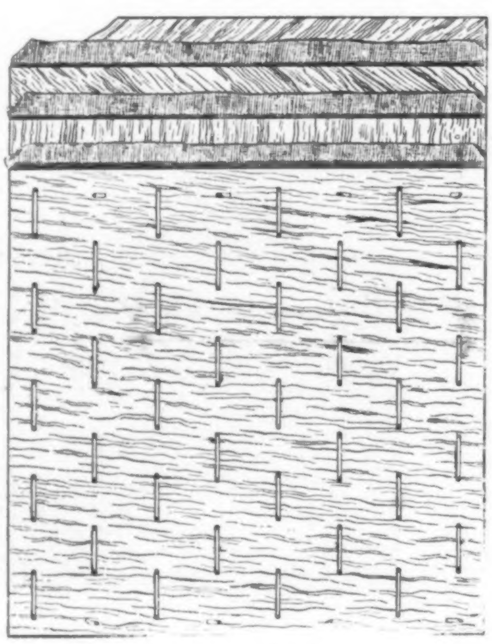
The method of fruit drying in this country has been vastly improved during the past decade. Happily the dark fly-specked product, dried in small quantities by exposure to the sunshine, has disappeared. A better grade prepared by artificially-heated evaporators of considerable capacity has been replaced by a superior quality bleached and evaporated by improved, cleanly methods in large plants having the ability to handle from two hundred and fifty to five hundred bushels of fruit or berries per day of twenty-four hours.

In the near future some of our chief foods will be condensed and evaporated by evaporation. Some years ago the writer purchased a hundred pounds of lean beef. After chopping it up finely it was reduced by careful drying seventy per cent in weight and about the same in bulk without any apparent loss in strength or flavor. Three heaping tablespoonfuls made my family of seven an ample quantity of good soup, or mixed with potatoes, an excellent hash. This desiccated meat requires no special means of preservation. I have kept a sample of it without damage for two years in a pasteboard box. By pressure it can be further reduced in bulk to a solid mass of any desired size or shape. In this form it would certainly be a valuable part of a ration for soldiers on a long march or for tourists in wild countries.

To Utilize Amber Waste.—The residual particles are treated for eight days with a mixture of equal parts of sulphide of carbon and ether in an hermetically-closed vessel, the fluid to be then poured off. The softened waste is packed tightly into iron molds, and at a temperature of 212 deg. F. subjected to as heavy a pressure as possible. The result is a solid substance that can be worked just the same as amber.

THE SAUNDERS SYSTEM OF SEWN BOATS.

MANY of the most famous and successful of the British racers, and a few of the French ones, have been built upon the so-called sewn system of construction, invented by S. E. Saunders, and now built by the Saunders Patent Launch Building Syndicate. The accompanying drawing shows the manner in which the Saunders construction is built up out of several layers of thin material. The frames of the boat are laid on the molds fore and aft, generally in one piece from end to end. Over this the inside planking is laid, varying in thickness according to the size and general design of the boat, from 1-16 to ¼ of an inch. In the cut the inside skin is laid diagonally in narrow strips. After this is in place, silk or cotton cloth is stretched tightly over it and painted with a composition, also the invention of Mr. Saunders, which remains semi-liquid for a very long period. Upon this the second layer of planking is placed, also diagonally and with the grain of the wood running at an angle of 90 degrees from that of the first layer. Another layer of cloth comes next and is made waterproof like the first; then another layer of thin planking. Each of these layers is secured by light nails to the longitudinals, so as to hold it in place until the sewing operation is ready to be gone through. The last layer of planking is put on with the grain fore and aft, and generally is considerably thicker than the others. When all is in place, the planking is drilled with a very fine drill, and alternate pairs of holes are connected on the outside by a groove put in by special machine. Then the whole structure is sewn together in and out with copper wire from gunwale to gunwale. The grooves on the outside allow the wire to lie flush or slightly below the outside skin, and it can then be smoothed up and sandpapered to a high finish. The paint or varnish with which the outer surface is covered fills all the



THE SAUNDERS SYSTEM.

holes so that there is no possibility of leakage, and it can be readily understood that such a structure is strong and yet elastic and highly suited for speed boats of any kind, or for conditions which require lightness in connection with strength. It is said that the total thickness of planking on some of the later Napier boats is only ⅜ of an inch, but in those racers only three layers of planking were used. The system is adaptable for boats up to 150 or 200 feet in length, by increasing the thickness of the planking and the gage of the wire used to fasten it together.

Some idea of the strength and lightness of this form of construction can be gained from the fact that "Napier II.," built on the Saunders principle, had a hull weighing not over half that of "Napier I.," the boats being of exactly similar model. "Napier I.," on account of her flat bottom and steel construction, was always springing a leak, while "Napier II.," of the Saunders construction, has never suffered in this respect. This form of construction is necessarily expensive and hard to repair, but the necessity of repair is very slight until after years of use, and a hull of this construction is likely to outlast the actual usefulness of the boat.

The first of the boats built on this plan came out in 1900 and was called the "Consuta." She was equipped with a high-pressure steam engine, and was used as a coaching launch and referee's boat upon the Thames. She was capable of over twenty miles per hour, a figure very high for that time. One of the most successful of Mr. Saunders's boats, aside from the racing standpoint, is the "Rattler," a boat which he built for India, to act as a pay boat and go up and down one of India's greatest rivers. "Rattler" is equipped with kerosene motors and twin screws, and is capable of very close to twenty miles per hour. Her work is important, carrying large sums of money, and to withstand the heat and climate she was constructed throughout of teak. She is said to have given great satisfaction, and that more boats of her kind will follow.

THE BIRTH AND AFFINITIES OF CRYSTALS.

IN the course of two Thursday afternoon lectures, delivered at the Royal Institution in the last two weeks, Prof. H. A. Miers, F.R.S., of Oxford, succeeded in demonstrating that there was a good deal to be learned yet from "crystal-gazing"—i.e., studying the growth of crystals under the microscope and under other conditions. As the slightest changes in temperature and concentration alter the phenomena, Prof. Miers exemplified some of his points by reproducing the photographs of Dr. Tutton and other investigators. But the successful demonstrations by Mr. T. V. Barker were still more instructive. We will very briefly indicate Prof. Miers's arguments.

Crystals cannot form unless the solution is saturated for the respective temperature. Saturation may be produced by evaporating the solvent or by cooling the solution. The crystallization can be started by dropping a small crystal of the respective salt into the solution, or by scratching the glass walls of the vessel with a rod; this, however, must be done in the solution, not before the solution is poured into the glass. When the liquid is kept very quiet it may be undercooled considerably, and therefore become strongly supersaturated; when a crystal of the salt (e.g., sodium sulphate or sodium acetate) is used to start the crystallization, the whole solution solidifies almost like a crystalline sponge. These facts have long been known. But Ostwald predicted two consecutive crystallizations, and Prof. Miers and his pupils have demonstrated them. Miss F. Isaac has cooled solutions in sealed tubes to keep out all germs and impurities, agitating the tubes all the time. As soon as saturation is reached a faint shower of crystals falls out; the cooling then proceeds until at a definite lower temperature a second, more profuse shower of crystals forms. These two states are observed in all solutions, in different solvents, in fused metals, alloys, rocks, and meteorites. If we plot temperature against concentration, we obtain two parallel curves, the upper curve corresponding to higher temperature and lower concentrations marking the saturation, the lower curve indicating the supersaturation or solubility. In aqueous solutions both the water and the salt may crystallize, and four cases are possible: the solution may be unsaturated for both substances, saturated for either of them, or saturated for both. The same applies to alloys, and we thus arrive at the complicated conditions with which the phase rule deals. According to Miss Isaac, pure water freezes spontaneously in sealed tubes at —1.9 deg. Cent., in the absence of any germs; when the agitated water contains particles of garnets, glass, etc., which produce mechanical friction, crystallization begins at —0.4 deg. Cent.*

The two growths of crystals mentioned are different in appearance. Whether the first is entirely spontaneous, or whether the presence of germs of the respective crystal—never absent, possibly, from the air—is essential, remains undecided; Prof. Miers inclines to the belief, however, that certain crystal germs are almost always present in laboratories, and many of his experiments are, therefore, made with rare organic compounds, like salol and betol. When a crystal grows very rapidly, under brisk evaporation, it shoots out like a long needle, because the change in concentration is less great at the apex than on the sides of the crystals; these variations in the density of the solution are studied by the aid of the refractive index. When two growing needles approach one another, they stop growing before they come into actual contact, and bend off under definite angles. Afterward, when the conditions change less rapidly, prismatic clusters are slowly formed round the needles; the two crystal shapes, needles and prisms, are the same, as proved by angle measurements, but the elongation along different axes gives the crystals a different appearance. A mutilated crystal, placed in a saturated solution of its own, grows into a perfect specimen. Other crystals attach themselves to certain faces, either in the same direction (parallel growth) or in different directions (twinning); individual crystals may be joined to more or less complete rings. But a twin crystal starts growing as such; it begins as a twin at its birth, and the twinning is a matter of structure.

Very interesting are the novel experiments on the growth of crystals on one another. If a solution of sodium nitrate is poured on a freshly split face of Iceland spar, the tiny nitrate crystals arrange themselves beautifully parallel, and with their edges parallel to the edges of the spar. Similar observations have been made concerning the crystallization of sodium nitrate on the carbonates of zinc, magnesium, iron, etc. All these carbonates, and the nitrate as well, crystallize in rhombic prisms, but the isomorphism is not complete—i.e., the angles under which the faces meet are not quite the same—and it seems to be more important that the two kinds of crystals, growing on one another, should have approximately the same molecular volume, than that their angles should be equal. Again, the alkali haloids (compounds of the alkali metals with chlorine, bromine, iodine, fluorine) will generally, but not always, crystallize in perfect regularity on one another. These haloids all crystallize in cubes, but while Rb Cl will grow regularly on K Cl, it will not grow regularly on Na Cl (rock salt). Mr. Barker, who is making a special study of these phenomena, has made 246 series of experiments on the many salts of the haloid group. Alkali permanganates and perchlorates also crystallize similarly on the sulphates of barium, strontium, and calcium. Now, similarly growing crystals also seem to be able to inoculate solutions,

* See Engineering, vol. lxxxii., page 312.

that is to say, to start crystallization in solutions of similar salts (in this sense), and Prof. Miers suggested that similar crystals may be due to similar rhythmical motions. These rhythmical motions would carry us a step further than Mr. Barlow's thesis of close packing, which means that crystals which can geometrically be fitted into one another are likely to grow under similar conditions.—Engineering.

ARTIFICIAL FERTILIZERS: THEIR NATURE AND FUNCTION.—I.*

By A. D. HALL, M.A., Director of the Rothamsted Experimental Station, Lawes Agricultural Trust.

THE NUTRITION OF THE PLANT.

In talking of an artificial manure, one has a perfectly clear idea of the meaning of the term; to find, however, a satisfactory definition is by no means easy. To the farmer certainly it means something which he receives in bags and applies to the land in hundredweights rather than tons per acre. With these two ideas in our mind—that we are dealing with an article of commerce, and with a concentrated one—we may dispense with any more formal definition of what constitutes an artificial fertilizer.

Nor, with the limited time at our disposal, need we spend much time over the early history of artificial manures. Men of an experimental turn of mind must have been putting all sorts of things on their land from the beginning of time. The virtues of gypsum and bones were certainly known to the Romans; and, to come down to more modern times, we find that a man like William Ellis, writing in 1736, was well acquainted with the use of such bodies as woolen rags, bones, soot, malt dust, and oil cake residues as manures. The real history of artificial fertilizers begins with the nineteenth century, because not until then was the knowledge of chemistry sufficiently advanced to provide any basis for a theory of the nutrition of the plant. Without such a theory all observation of the good effect of this or that substance on the crop was merely empiric and possessed no value beyond the occasion.

To trace the building up of our accepted conception of the course of a plant's nutrition would make an interesting story, in which Priestley, de Saussure, and Liebig are the outstanding names, though many others played their parts, either creative or controversial; but it would require a lecture for itself. In the main, though there are by-paths still to be explored, the great issues may be considered as settled; indeed they are just beginning to receive the final sanction of age and orthodoxy in the shape of the assaults of the crank, who starting *de novo*, rediscovers all errors and fallacies which the old masters had patiently and laboriously cleared away.

If we take any living plant and reduce it to its elements we find but a small range of substances; water forms the greater portion of the plant, the rest is almost wholly composed of compounds of carbon with hydrogen and oxygen, approximately in the proportions which make up water. Of the dry matter of the plant at least half is carbon; oxygen and hydrogen constitute most of the remainder; then a certain restricted number of other elements are present in much smaller quantities. Nitrogen constitutes 2 per cent of the dry matter; the others, which are found in the ash when the plant is burnt, make up a further 2 per cent. These ash constituents comprise sulphur, phosphorus, silicon, and chlorine among the non-metals; potassium, sodium, calcium, magnesium, and a little iron and manganese among the metals. Traces of other metals occur from time to time in the ashes of plants growing on soils which happen to contain them, but they are unessential and may in this connection be neglected.

Carbon then is the main element in the plant's economy, and we know that it is obtained by the plant from the carbonic acid in the atmosphere, through the agency of the living cells in the leaf which contain green chlorophyl. The carbonic acid is taken in through the small openings in the skin of the leaf, the stomata; it is decomposed by the chlorophyl-containing cells and the carbon is retained in combination with the elements of water, so that it is first identifiable as sugar and then as starch, at the same time oxygen is returned to the atmosphere. This decomposition is one which necessitates an external supply of energy, which is found to be derived from the light incident upon the leaf, the process stopping in darkness, and for low illuminations becoming proportional to the amount of light falling upon the leaf.

The conditions affecting this process of photo-synthesis, the fundamental reaction of the whole plant world, have been subjected to considerable examination of late. In the method which has been adopted by Dr. H. T. Brown, the leaf, which may still be attached to the plant, is inclosed in a flat air-tight box with glass sides, through which sweeps a rapid but measured current of air. The issuing air which has passed over the leaf is led into an apparatus for the determination of the carbonic acid (and if need be of the water) it contains; at the same time a parallel experiment without the leaf measures the proportion of carbonic acid and water in the incoming air. Thus the amount of carbonic acid absorbed, and therefore decomposed, in a given time by a leaf, whose area can be afterward measured, is directly determined, and such factors as illumination, temperature, can be varied at will. The energetics of the process have been worked out by Dr. Brown and Mr. Escombe, from whose paper the following examples have been selected:

* From the Journal of the Society of Arts.

TABLE I.

Plant.	CO_2 Absorbed per Sq. Dm. of Leaf per Hour, C.c.	Water Transpired, Grammes.	Energy in Calories per Sq. Cm. of Leaf per Minute. Solar Radiation Falling on Leaf.	Solar Radiation Absorbed by Leaf.	Energy Required for Assimilation.	Energy Required for Transpiration.	Energy Lost by Radiation and Convection.
Polygonum, June 19....	3.758	1.054	0.1942	0.1256	0.0031	0.1041	0.0184
Tropœolum, September 4	1.498	0.141	0.0889	0.0622	0.0012	0.0139	0.0471
Helianthus, August 4...	2.134	1.259	0.2569	0.1762	0.0017	0.1243	0.0502

These experiments show that the leaf of a plant is not to be regarded as a very efficient machine for the decomposition of carbonic acid, since in no case was more than 1.66 per cent of the total incident energy on the leaf used for photo-synthesis, so that even dull, diffuse daylight can amply provide a growing plant with the energy it wants for assimilation. The process, however, is limited by many factors, any one of which may fix a minimum rate at which assimilation will take place, however favorable the other conditions are. Temperature, the supply of water, the proportion of carbonic acid in the air, the number and area of the stomatic openings, are all limiting factors of this kind, as also is the supply of other nutriment to the plant. To take an example which bears more particularly on the subject of these lectures: if we compare two of the Rothamsted mangel plots (see Table II.), which receive the same supply of nitrogen and phosphoric acid, we find that they produce approximately the same weight of leaf; indeed the similarity would be still closer if the comparison were made when the leaves were in full activity, and not at the end

1 2 3 4 5 6

WATER CULTURES OF BARLEY.

1. Complete manure. 2. No nitrogen. 3. No phosphoric acid. 4. No potash. 5. No lime. 6. No magnesia.

of the growing season. One plot, however, receives a dressing of potash salts, but not the other, and the plot with potash produces nearly $2\frac{1}{2}$ times the weight of roots grown upon the other plot without potash. Now this difference in weight is almost wholly due to sugar and other carbo-hydrates, which were manufactured in the leaf and then passed on to the root for storage, yet the two plots possessed practically the same leaf development working under identical conditions of illumination, carbon dioxide, and water supply. But in one case the photo-synthetical process had been limited by the want of potash; all the machinery was there and the power was in excess, but the machinery was running idle for the lack of one necessary link—in this case the potash. (See Table II.)

Though the compounds of carbon with hydrogen and oxygen make up so much of the solid matter of the plant, the remaining substances, comparatively

TABLE II.

PRODUCE OF MANGELS AT ROTHAMSTED, 1900.

Plot.	Manure.	Leaf per Acre.	Roots per Acre.	Sugar per Acre.
		Tons.	Tons.	Tons.
5A	Nitrate of soda & superphosphate	2·95	12·00	0·797
4A	Nitrate of soda, superphosphate & potash	3·25	28·95	2·223

small in amount as they are, are still all important to the process of growth. The part they respectively play and their mode of entry can best be illustrated by the method of water cultures, of which Fig. 1 shows an example. By this method the roots of young seedling plants are just allowed to dip into a large jar of water in which salts of the elements found in the plant are dissolved. A complete solution might be made up as follows:

	Grammes per liter.
Calcium nitrate	0.7
Potassium phosphate	0.6
Potassium chloride	0.8
Magnesium sulphate	0.3

With a trace of ferric chloride.

This will contain all the elements, except silicon, normally found in plant ashes, and under such conditions the plant will grow and go through its whole cycle of life, assimilating freely, producing large quantities of dry matter, setting flowers, and ripening healthy seed. Certain precautions have to be taken, but if the right conditions are assured, the growth of a plant in a water culture is perfectly normal, and may be taken, as far as the plant is concerned, as representing the course of its nutrition in the field. The advantage of the method lies in the fact that it is possible to vary the composition of the nutrient solution by omitting in turn from successive jars each of the salts used in making up the complete solution, thus obtaining media for the plant containing no nitrogen, no phosphorus, no potassium, etc., the other constituents found in the plant being present in each case. The result of one such series of experiments is shown in Fig. 1, which illustrates that when, e. g., nitrates are omitted from the culture solution the plant is quite unable to grow after it has used up the material in the seed, however freely it may have been provided with potassium, magnesium, etc. The net result of such experiments, in agreement with the one shown in the photograph, is that a plant must obtain by means of its root its nitrogen and its ash constituents from simple inorganic compounds dissolved in the water.

Of the elements found in the plant, nitrogen in combination, phosphorus, sulphur, potassium, magnesium, calcium, and a little iron are indispensable to the growth of the plant and cannot be omitted from the culture solutions. Sodium, silicon, and probably chlorine, though invariable constituents of the ash, are not necessary and can be dispensed with. From these water-culture experiments we arrive, then, at the conclusion that the plant must draw certain elements, in quantities which are small indeed compared with the weight of the crop but nevertheless indispensable, out of the soil by means of its roots, the rest of the plant being built up from air and water. The further deduction would appear to be simple, that the manure a plant wants will consist simply in these bodies, other than carbon, hydrogen, and oxygen, which are mainly left behind when a plant is burnt. Indeed, it was on these lines that Liebig, who first of all devised a theory of manuring, proceeded to construct an artificial fertilizer. Put into the soil, he said, exactly what a good crop of the kind normally removes, and you have satisfied all the manurial conditions necessary for a maximum crop; and on this basis manures were compounded for the various crops, which, however, failed to satisfy the farmer who used them. Not only did Liebig's own manures prove a failure, but his theory of manuring was rudely traversed by the field experiments which Lawes and Gilbert had just begun in this country. His theory, indeed, true enough for a water culture, breaks down in the field because it takes no account of the soil; and the soil is not merely an inert medium to anchor the plant and convey the manure to it when convenient, but contains itself an enormous potential reserve of plant food.

We may take, by way of an example, the Rothamsted soil. On the one hand, it is neither richer nor poorer than the majority of British soils and it has no abnormal characteristic, but may be taken as a very fair average type; on the other hand, there is no other soil about which so much knowledge has been accumulated.

The accompanying analysis shows, as usual, that

TABLE III.—ANALYSIS OF THE SOIL OF BROADBALK FIELD, ROTHAMSTED, UNMANURED FOR 50 YEARS.

	Per Cent.	Per Cent.	Lb. per Acre.
Loss on Ignition	4·20	..	..
Containing Carbon ..	..	0·89	22,250
„ Nitrogen ..	..	0·10	2,500
Matter soluble in hydrochloric acid	12·53	..	..
Containing Soda ..	..	0·06	1,500
„ Potash ..	..	0·27	6,750
„ Magnesia.	..	0·36	9,000
„ Lime	..	2·49	62,250
„ Alumina .	..	4·49	112,250
„ Oxide of iron ..	..	3·40	85,000
„ Phosphoric acid	..	0·11	2,750
„ Sulphuric acid ..	..	0 05	1,250
„ Carbonic acid ..	..	1·30	32,500
Undissolved siliceous matter	83·27	..	..

the greater part of the soil consists of insoluble siliceous matter of which no account need be taken; there

is further a certain amount of organic material, important as containing a store of nitrogen which may eventually reach the plant. In addition, we have various acids and salts going into solution in the acids used for the analytical process, and these include precisely the substances that have already been indicated as constituents of the ash of plants; among metals, calcium, magnesium, potassium, sodium, with iron and aluminium in quite disproportionate amounts, sulphuric and phosphoric acids, chlorine and silica to supply the non-metals. Read as percentages, some of these amounts seem small enough, but they represent enormous quantities of material in the soil, as will be realized when they are correlated with the fact that the layer of soil at Rothamsted, nine inches deep, which is taken for analysis, weighs over the area of one acre rather more than two and a half million pounds. Translating, then, the percentages into pounds per acre, 0.1 per cent of nitrogen becomes 2,500 pounds, 0.11 of phosphoric acid becomes 2,750 pounds, and the potash rises to 6,750 pounds; also these quantities are in the surface soil only without considering the lower layers into which the plant roots penetrate freely. A comparison of the materials in the soil with those taken away by ordinary crops at once leads to results which seem paradoxical, so much greater is the stock of plant food in the soil than any requirements of the crop that further additions of the same stuff in the shape of fertilizers would seem to be needless. The accompanying table (IV.) shows the amounts of various materials per acre which are on

TABLE IV.—Soil Constituents contained in Average Crops.

	Wheat	Barley.	Swedes	Mangels.	Hay.
Crop .... Tons	2·2	2·0	16·1	30·1	1·5
Nitrogen ...lb.	50	49	98	149	49
Soda ......lb.	2·6	5·0	32·0	118·7	9·2
Potash ....lb.	28·8	35·7	79·7	300·7	50·9
Magnesia ..lb.	7·1	6·9	9·2	42·5	14·4
Lime ......lb.	9·2	9·2	42·4	42·9	32·1
Phosphoric acid lb.	21·1	20·7	21·7	52·9	12·3
Sulphur ....lb.	7·8	6·1	17·8	14·0	5·7
Chlorine ....lb.	2·5	4·1	15·1	83·1	14·6
Silica . ....lb.	96·9	68·6	6·7	17·9	56·9

the average drawn from the soil by various crops at Rothamsted.

Roughly speaking an average soil contains enough plant food for a hundred full crops, yet without fresh additions of plant food as manures the production will shrink in a very few years to one-third or one-fourth of the average full crop. Once, however, the yield has reached this lower level it will remain comparatively stationary, affected only by the fluctuations due to season, for an indefinite period. At Rothamsted, for example, wheat has now been grown year after year on the same land for sixty-three seasons, and one plot has received no manure throughout the whole period. In the first few years the crop declined steadily, but since then little or no further drop can be seen. The yield remains at about twelve and one-half bushels per acre for each successive ten years' average, and has considerably overtopped that amount during the last two favorable seasons. This yield, however, of twelve and one-half bushels of corn per acre is only about a third of that obtained on the adjacent plots receiving manure every year during the same period.

These facts lead to a new point of view. It is not merely the amount of this or that plant food present in the soil which must be taken into account, but also their mode of combination. The material may be present in the soil and soluble in the acid used for analysis, but yet may be beyond the reach of the plant in a locked-up or dormant condition. The plant can only obtain substances which have been previously dissolved in the water contained by soils in the field, hence plant food in the soil is only available for the plant in so far as it can pass into solution. It has been maintained that the roots of the plant itself, in virtue of the acid cell-sap they contain, are capable of exerting a strong solvent action on such insoluble materials of plant nutrition as calcium phosphate, but investigations of this question from various points of view lead to the conclusion that no such external action of the root sap is possible, but that the carbon dioxide excreted by the roots does assist the solvent action of the soil water. The apparent paradox of a soil being poor or impoverished while yet containing enough plant food to furnish a hundred crops or more is thus explained by the comparative insolubility of these reserves, which can only become available to the plant by passing into solution. To use an illustration, the plant food in the soil may be represented by the capital a man may have locked up in a particular business, the available plant food will correspond to the cash in hand, which may often run dangerously short, however great the capital involved. Similarly a good many of the operations of cultivation have for their end the bringing of the capital of the soil into a circulating form as rapidly as possible and the realization of a profit from it.

Accepting then the fact that the soil contains a vast store of all the elements necessary to its nutrition but in forms more or less available, it remains to ascertain which of the substances are normally likely to fall below the current requirements of the crop. This is a question that can only be solved by field experiments, and though the solution will vary with each crop and each soil yet certain general principles at once become evident, and upon them the whole idea of a fertilizer is based. For example, field experiments at once show that certain elements indispensable to the plant, as seen from water-culture experiments, need not be supplied to the crop in the field, since the soil is practically always able to provide a sufficiency. Calcium, magnesium, iron, sulphur, chlorine, and silicon fall into this class; to judge by field experiments alone there are only three elements necessary to the nutrition of the crop, nitrogen, phosphorus, and potassium, which means that soils can usually supply enough of the elements necessary to the plant excepting only of these three. Fertilizers, then, are designed to supply deficiencies in the soil and for all practical purposes are to be regarded as containing compounds of nitrogen, phosphoric acid, and potash, either singly or together. They may also contain magnesia, lime, or sulphuric acid, but these, though equally necessary to the plant, are not counted, since the unaided soil may be trusted to furnish the crop with them.

To illustrate the part played by the soil, a comparison may be drawn between the water-cultures of barley previously illustrated and the results of the Rothamsted experiments upon the same crop grown continuously for over fifty years on the same land. The same series of nutrient substances were employed in both cases, and in the field trials, as in the water-cultures, the part played by any element can best be seen from the result produced by omitting it from a complete manure:

TABLE V.—Experiments upon Barley, Hoos Field, Rothamsted.

Plot.	Character of manuringe	Yield—Bushels of Grain.	
		Whole period 51 years.	Last 10 years only.
1-O	Unmanured	15·3	10·1
4-O	Without nitrogen	20·4	12·4
3-A	Without phosphoric acid	29·4	20·8
2-A	Without potash	39·9	26·8
4-A	Complete manure	42·1	35·1

From this it will be seen that the soil alone is capable of producing a crop which, if small, yet amounts to over a third of that obtained with a complete manure. The omission of potash results in a small diminution of crop, the omission of phosphoric acid in a much larger one, while in the absence of nitrogen the yield falls to less than half, almost to that of the unmanured plot. Of course, in a water-culture the omission of any one of these elements would have reduced the growth to a minimum; in the field the soil has been able to meet the requirements of the plant fairly well as regards potash, less so for phosphoric acid, and very indifferently as regards nitrogen. That the soil is drawing in capital to supply the crop may be seen by comparing the results from the omission of potash over the whole period, and for the last ten years; over the whole period the decline in the yield produced by the omission of potash is only 5.2 per cent, but during the last decade this decline has risen to 23.6 per cent, an indication that the supply of potash originally available for the crop has been largely exhausted.

This experiment also illustrates another difficulty that is experienced in framing a theory of fertilizers; the analysis of a plant, though it would enable one to make up a solution suitable for its growth in water-culture, is no guide to the amounts of the various fertilizers to be supplied to the same plant when growing as a field crop. For example, analysis shows that an average barley crop removes from the soil about 49 pounds of nitrogen, 21 pounds of phosphoric acid, and 36 pounds of potash per acre; yet the addition of 43 pounds of nitrogen raises the crop from 20.4 to 42.1 bushels per acre, or by 51.5 per cent of the crop on the standard completely-manured crop; the addition of 63 pounds of phosphoric acid produces an increase of 12.7 bushels; while the addition of 100 pounds of potash, the element most abundant in the ash, only causes an increased yield of 5.2 per cent.

To take another example. An average crop of swedes will remove from the soil 98 pounds of nitrogen, 22 pounds of phosphoric acid, and 80 pounds of potash; but, so far from the swede crop requiring a fertilizer which is mainly nitrogenous and potassic, all field experiments and long farming experience go to show that swedes require little beyond phosphoric acid as a manure, with a small amount of nitrogen and potash only in rare cases.

No theory of fertilizers then can be based on the composition of the plant alone. The amount of plant food must also be taken into account, and not only its amount but its availability, which will vary to a considerable extent with the different crops. Growing plants of different species show widely differing powers of obtaining for themselves from the reserves in the soil the quantity of this or that plant food which they require; those differences depending on such factors as the depth or extent of the root range, the duration of growth and the period of the year at which it takes place, etc. For example, compare the effect of withholding potash in the fertilizer from three of the crops under experiment at Rothamsted—wheat, barley, and mangels.

As all three crops are grown on soils which are practically identical, this table shows that barley is much better able to use the reserves of potash in the soil than are either wheat or mangels, the latter crop being particularly dependent upon a large supply of potash in the fertilizer.

TABLE VI.—Effect of Potash on various crops grown continuously.

	Manures.		Per cent. increase due to potash.	Potash, pound per acre removed by crop (average).
	Nitrogen and phosphoric acid.	Nitrogen phosphoric acid and potash.		
	Yield. (bushels)	Yield. (bushels)		
Wheat ...... (51 years)	24·0	31·5	31·2	28·8
Barley ...... (51 years)	39·9	42·1	5·2	35·7
Mangels ..... (27 years)	(tons.) 7·66	(tons.) 14·03	83·2	300·7

The fertilizer that a crop particularly requires is the substance that it finds some special difficulty in obtaining from the reserves in the soil; and this difficulty may be indicated by a comparative deficiency of the substance in question in the plant's analysis, just as the swede crop, which is particularly in need of phosphoric acid, only removes of it 22 pounds per acre, as against 98 pounds of nitrogen and 80 pounds of potash.

But while it is true that for each of our farm crops we can indicate what Ville has called a "dominant" fertilizer, nitrogen for wheat, phosphoric acid for swedes, potash and nitrogen for mangels, meaning thereby that if the crop is well supplied with its "dominant" by means of fertilizers, it can generally pick up the remaining elements of nutrition from the soil reserves, yet this "dominant" is hardly to be discovered from a consideration of the analysis of the plant. Field experiments form the only guide to the manurial requirements of any plant, field experiments carried on for a sufficient length of time to eliminate accidental variations in the results due to soil and season. Such field experiments have been carried out for wheat, barley, oats, grass, potatoes, mangels, and turnips; but for many other crops of considerable importance, particularly in market gardening, this fundamental knowledge of the plant requirements has not yet been ascertained.

A complete theory of manuring will always have two points of view, one special to the crop, the other to the soil; on good all-round soils, fertile loams and the like, the composition of the fertilizer employed will be dictated by the nature of the crop; on the more specialized soils, as on the pure sands, heavy clays or peats, it will depend primarily upon the soil.

It is on these special soils that Liebig's "law of the minimum" is chiefly seen to operate; if any one of the elements necessary to a plant's nutrition is deficient then it is the supply of that particular substance which will determine the yield of the crop, however abundant the other elements may be. This law of the minimum may, indeed, be extended more widely to include other factors than the supply of fertilizers; temperature, water supply, the texture of the soil, are all "limiting factors" in the nutrition of the plant, any one of which may so determine its growth that variations in the other factors are of no account. Thus it is not uncommonly seen that in an exceptionally dry season a series of experimental plots may show little or no variation in the results due to the different manures; on each plot the crop grows as far as the limited water supply will allow it, and for this small development there is in each case an excess of all kinds of plant food to be obtained from the soil. In a wetter season of abundant growth it may be the supply of potash or phosphoric acid gives out on one or other plot, whereupon that becomes the limiting factor determining the yield.

To summarize then the position we have reached—a fertilizer must contain one or more of the three substances, nitrogen, phosphoric acid, and potash, which alone among the various elements necessary to the nutrition of the plant cannot be supplied by cultivated soils in amounts sufficient for profitable crop production. The soils do contain these substances in comparatively enormous quantities, but the distinguishing feature of a fertilizer which makes it effective when supplied in quantities comparable with those removed by the crop, is its "availability."

(To be continued.)

THE ENRICHMENT OF LIQUID FUELS.

In spite of all the improvements effected in explosion motors and their carbureters, the fuel employed, according to a writer in La Locomotion Automobile, must not exceed 710 deg. in density without recourse to some artificial means of accelerating vaporization. This is the case with motors using refined oil, and with various marine motors in which heat is resorted to as a means of ignition. In Germany an attempt has been made to solve the problem by the addition to the fuel of a substance which can be ignited at the ordinary temperature, and Dr. C. Roth, the inventor of roburite, has succeeded in making the free fuels more explosive by this means. The chemical substances he adds to the hydrocarbons are nitrate of ammonium, either alone, or in combination with nitric products. Nitrate of ammonium is a product of nitric acid and ammonia; it is a neutral salt and completely soluble in half the quantity of water and three volumes of alcohol. Burned in free air it produces laughing gas; its formula is

NH_4NO_3. Mixed with fuels, such as petroleum spirit, alcohol, etc., this salt burns without a solid residue, forming water and free nitrogen and releasing oxygen, which combines with the carbon and the hydrogen of petroleum, gasoline, alcohol, etc., yielding carbonic anhydride and water.

The oxygen released by the decomposition of the nitrate of ammonium is not the same as the atmospheric oxygen, but is set free in its nascent form, a condition very favorable to its combination with the fuel substance. This addition of oxygen to the hydrogen and the carbon of gasoline accelerates the explosion, and consequently augments the power of the motor. The nitrate of ammonium is not soluble in hydrocarbons alone, and in introducing it, it is necessary to employ the following method: To dissolve it in a certain quantity of alcohol and add this solution to the hydrocarbon.

Another German scientist, Prof. Cantor, proposes the employment of a solution of oxide of copper in the gasoline. The metallic oxides, however, like the alkaline chlorides, possess a peculiarity which prohibits their utilization in motors; they leave a solid residue, which is deposited on the cylinder, the piston, and the valves, corroding them more or less; as the nitrate of ammonia is consumed without leaving any deposit, it is excellent for the proposed purpose.

The fact cannot be overlooked, that racing vehicles have occasionally been subjected to a "doping" process, consisting of the addition of picric acid to the gasoline. The less said of the use of this substance the better, on account of its dangerously explosive properties and the activity with which it attacks metals. The most effective use of nitrate of ammonium is made in gaseous conditions, the following combinations being quoted:

I.—90 parts, by weight, of 88 per cent alcohol.
10 parts of nitrate of ammonium.

II.—80 parts of 90 per cent alcohol.
4 parts of nitrate of ammonium.
1 part of dinitro benzine.

III.—75 parts of alcohol.
15 parts of benzine.
5 parts of kerosene.
3 parts of nitrate of ammonium.
1 part of dinitro benzine.
1 part of nitrate of ethyl.

The force of the explosion could be augmented by the use of nitrogen-glycerine or gun cotton, but these substances are too destructive for practical motors. Brake tests have demonstrated that an addition of 8 per cent of nitrate of ammonium, which left no residue whatever, gave an increase of power equivalent to 10 per cent, without the least risk of injury to the mechanical parts of the motor. The addition of nitrate of ammonium may be carried as far as 10 per cent, without inconvenience, and the expense of the addition is largely repaid in increased power.

Two reservoirs could be installed, one containing the ordinary gasoline for the development of normal speeds, the other for nitrated spirit for long runs and for use in all cases where an increase of power is desirable.—The Motor Boat.

THE SANITARY ENGINEERING PROBLEMS OF WATER SUPPLY AND SEWAGE DISPOSAL IN NEW YORK CITY.*

By GEORGE A. SOPER.

THE Section on Public Health of the New York Academy of Medicine is formed at a peculiarly opportune time. Never before has sanitary information of a reliable, authentic character been so much desired by the public, nor so difficult for the public to obtain.

Our great universities have, for the most part, failed to recognize the vast popular and educational value which would attach to the establishment of adequate facilities for teaching sanitary science, hygiene, public health or preventive medicine, as that body of knowledge which relates to the prevention of disease is variously termed, and have left this kind of teaching largely to the newspapers and to the general practitioner of medicine. Unfortunately, physicians do not always appreciate their importance as sanitary teachers.

It is in consequence of this that vast stores of scientific facts which are being constantly collected, and which bear upon the causes and ways of preventing disease, are locked up in severely technical journals or brought out, often with an entirely mistaken interpretation, in the public press.

Aside from the collection of new sanitary facts, therefore, the members of this section can perform an extremely valuable service in assimilating the data made available by scientists and other busy workers and help to mold public opinion toward a proper consideration of the endless number of topics which relate to the public health.

The beneficial fruits of these labors will certainly be far-reaching. It has been well said that the eyes of the whole country are upon the metropolis. To a considerable extent what is found to be good here is likely to be thought desirable elsewhere.

At the initiation of this section, it may be well to take a brief glance at some of the larger sanitary engineering problems which now concern New York and consider how, in view of present and future circumstances, these problems should be studied.

We have in New York a singularly good example of a city of the largest class, wherein the highest requirements of sanitation are demanded and are, at the same time, capable of being satisfied. The population is not only great; it is concentrated, and in race, habit and social condition, exceedingly diverse. Practically all of the conditions necessary to maintain life in a wholesome way have to be secured through a most careful observance of sanitary rules and principles. This relates not only to the food, clothing and habitations of the people, but in a peculiar degree to the care of their wastes and the wastes of those who have to do with the city's food and drink. Upon the prompt and adequate disposal of these wastes largely depends the security of the city against disease.

These, in the briefest terms, appear to be the necessities of the present. What the exactions of the future will be, when more refined standards of hygiene are established and the public sense of decency and morality becomes correspondingly elevated, it is impossible to say. It is evident that the subjects which are to concern our future guardians of public health are not to be related solely to the more obvious causes of disease.

Thus far, in the history of sanitation, the great strides of progress have usually resulted from emergencies, most of which have pointed in a striking manner to the fact that the grosser human wastes were not being properly dealt with. Unfortunately this method of progress still prevails to a great extent through the country, as witness the large quantities of filth of all kinds which accumulate in our northern villages and cities through the winter, and the epidemics of typhoid fever which occur every year.

Sanitary emergencies, such, for example, as infected water supplies, capable of producing epidemics, now rarely occur in our largest centers of population and are no longer to be expected in the city of New York, which rightfully boasts one of the most efficient health administrations known anywhere.

Sanitation in cities of this class now and in future may be expected to progress along more scientific and conservative lines. The conditions to be avoided must be discovered and corrected as far as possible before they result in nuisance or disease. Large schemes for sanitary improvement must be made and made after careful investigation and preparation while yet there is ample time.

Two large sanitary engineering problems which now confront the city of New York are being studied in this manner, and as they well illustrate what is meant by these remarks, they will be briefly referred to.

The water supply is being enlarged. Competent authorities have studied the matter exhaustively and decided upon what it is best to do. This problem has now entered upon its second stage, that of construction.

The project is, as you know, to enlarge the supply of all the boroughs of the city by bringing water from the Catskill Mountains. The quantity to be delivered will be from 80,000,000 to 150,000,000 gallons per twenty-four hours at first, and will probably reach 500,000,000 gallons, or more, in time. It is estimated that this, with the present sources of supply, should be enough to meet the needs of the increasing population until 1925. The present supply of Croton, which is consumed in Manhattan and Bronx, is about 292,000,000 gallons per day with a per day increase each year of 14,000,000 gallons, as shown by the records of consumption for the last ten years.

The quality of the new water will be superior to that of the Croton. It will be softer to begin with, and will be filtered through slow sand filter beds, located near White Plains, such as have been extensively used in various parts of Europe and America for many years. It is practically certain that the Croton supply will be filtered in the same manner.

Although a part of the new water will be available for the boroughs of Brooklyn and Staten Island, it is considered highly desirable that Brooklyn, if possible, should avail itself of supplies now stored in the sands of Long Island east of the present sources of supply.

As pointed out by the mayor, in his message of January 7, 1907, since the New York Board of Water Supply was appointed in June, 1905, remarkable progress has been made by its engineers in the preliminary work necessary to construction. About 40 per cent of the line of the principal aqueduct of 86 miles from the Catskills to what is known as the Hill View reservoir, located near Yonkers, has been located, as has the site of the dam for the great Ashokan reservoir, and the 10,000 acres of the reservoir itself. About 15 per cent of this aqueduct has been prepared for contract. To accomplish this result, 550 miles of surveys and 12 miles of sub-surface borings have been made.

At this rate of progress, it would not be surprising if water from this new source would be available considerably within the eight years allowed by the engineers.

As pointed out by the mayor, the new water supply is to cost over $160,000,000 and it is highly desirable that the taxpayers should understand the benefits to accrue from it.

The need of this work did not arise from any emergency. No epidemic pointed to its necessity. The work is being carried out largely in anticipation of the needs of the future, as pointed out with infallible accuracy by the teachings of sanitary science.

The problem of disposing of the sewage of New York and neighboring municipalities so that it shall not create a nuisance, or in other ways interfere with health, comfort or convenience has been the subject of official study for three years, and is likely to continue to be investigated for several years to come. And the question here is not so much to improve present conditions, although this object may be accomplished in the end, as to protect our tidal waters against the vastly increasing pollution of the future.

Hitherto there has been no question as to the efficacy of the method of sewage disposal pursued by New York and its neighboring municipalities. House sewage and street washings have been discharged, without purification of any kind, into the nearest tide waters. Recently, communities remote from the shore have joined together to bring their combined sewage through miles of sewers to the bay. One of these projects is unprecedented in the quantity of sewage to be carried. By a curious coincidence, the contemplated point of discharge is near the statue of Liberty Enlightening the World.

To say the least, it is disquieting to contemplate the discharge of so much potential danger into the waters which flow by our doors; which so many of us cross and recross daily; which is the scene of many of our most imposing national and municipal pageants; where some of us bathe—and many of us get our oysters.

If the wastes are rendered innocuous, they are destroyed in ways which are not understood. Our knowledge of the fate of the sewage of New York may be said to extend no farther than the outfalls of the sewers.

It is unwise to count blindly upon the purifying action of sea water and the tides, for to what extent the flow of the ocean in and about the great rivers and harbors which intersect the metropolitan district transports and renders innocuous the five hundred million gallons of dangerous matters which are discharged into them every day, it is impossible to say.

Perhaps the sewage is flushed out to sea; perhaps it is consumed by minute animals and plants; perhaps some of it is turned into gas, some into liquids, some oxidized or burnt up by the nitrifying bacteria in the water. Perhaps much of it is stored in pockets and sludge banks until freshets in the Hudson flush it out to sea. We do not know what becomes of it.

Obviously, the harbor, as a whole, has a large digestive capacity for sewage, but it would be curious, indeed, if that capacity had no limit. There are few persons who have been actively interested in studying this problem who do not consider that eventually some other method of sewage disposal than the present one will be necessary for a large part of the Metropolitan District. It is only a question of time. How long, nobody knows.

These two questions, the supply of pure water and the disposal of this water after it has been turned into sewage are sanitary problems of the largest kind. The estimated cost of constructing the new water works of New York exceeds the estimated cost of building the Panama Canal. If it becomes necessary to collect and purify all of the sewage of the metropolitan district, it may be a costlier task still.

The highest skill, wisdom and efficiency are none too great to enlist in devising safe and suitable works of such magnitude. The sciences of pathology, chemistry, biology, physics, meteorology and mechanics must contribute generously to the fund of information necessary in order that the plans may be brought to that high point of perfection which engineers characterize as "necessary and sufficient" in their works.

And there is another consideration which has, so far, received little thought, but which must be taken into account in dealing with the sewage disposal problem. For work to be done at all, it must be done within permissible limits of cost. The charter of New York, which intentionally omits to restrict expenditures for water supply, confines the cost of sewerage and sewage disposal to within the constitutional debt limits of the city.

In thus giving emphasis to two of the problems which New York is attempting to solve, it is not intended to draw attention from other sanitary engineering problems, some of which are of almost equal prominence.

The double problem of cleaning the streets and disposing of the wastes so collected is one of the greatest magnitude. It costs the city over $6,000,000 per year to maintain the department of street cleaning. In no other comparable city in the civilized world is this question in such unsatisfactory shape or so difficult to cope with, under the practical conditions which exist, as in the metropolitan district which we are considering.

The time will come when New York city will insist upon clean streets and find a way to have them. Eventually the public will demand that the refuse from our tables, kitchens and factories shall be disposed of at a minimum of offense and a maximum of economy and despatch. But until this problem is made the subject of competent study and a broad, comprehensive plan of administration and procedure is laid down, we may expect slow improvement in the primitive methods which have always been an offense to the eyes and nose in New York city.

The solution of this problem is probably far beyond the unaided capacity of any person who may be placed at the head of the street-cleaning department, and these remarks, therefore, reflect in no wise upon the ability of any official of the city, past, present or future. If it can be solved at all, and there is a very general impression that it can, the problem can be solved only as the other great sanitary engineering problems of New York have been, and are being, solved. That is, with the help of qualified experts, acting without prejudice, political bias or other ambition than to serve the best interests of the city.

* Address delivered at the opening of a Section on Public Health of the New York Academy of Medicine.

THE OPERATION OF MECHANICAL DEVICES AT A DISTANCE BY MEANS OF THE WIRELESS TRANSMISSION OF ENERGY.

By DR. ALFRED GRADENWITZ.

SINCE the invention of wireless telegraphy which in so short a time has attained almost universal importance, many attempts have been made to transmit to a distance mechanical effects, as well as telegraphic messages, without the use of conducting wires, and thus to operate mechanical devices wherever situated, for example, the motor of a boat or an airship, or the dynamos of an electric power station. For the proper understanding of this problem a brief review of the fundamental principles of wireless telegraphy is required.

Although Marconi was the first—if we except Popoff's experiments—to effect the practical transmission of messages by means of aerial electric waves, the principle of wireless telegraphy was established by Branly, who in 1890 discovered that a tube filled with metal filings is converted temporarily into a good conductor of electricity by the influence of electric waves. Branly's tubes were made of glass or other non-conducting substance and contained metal filings compressed between two metal electrodes. Because of the imperfect contact of the filings no current ordinarily flows through such a tube when the electrodes are connected with the poles of a battery, but if an electric spark is produced near the tube the latter becomes a conductor and allows the battery current to pass and deflect a galvanometer included in the circuit. But a sharp blow on the tube destroys the conductivity and the current ceases. This apparatus, called a coherer or radio-conductor, is the corner stone of wireless telegraphy. The fundamental experiment is illustrated in Fig. 5 which shows at the left the electrical circuit including the battery, galvanometer, and coherer, and at the right the induction coil which produces the electric sparks.

The influence of an electric spark which is thus detected by the coherer is propagated with equal intensity in all directions, with the velocity of light, through air and other non-conductors, including pure water and masonry walls, but it is arrested by metals, metallic solutions, and salt water. It can be detected at a distance of several hundred yards, and at a much greater distance with the aid of long metal rods called antennas. The effect is due to the electric oscillations which are produced simultaneously with the light and sound of the spark. We possess special organs by which we perceive the light and sound but the electric waves can be detected only with the aid of the coherer which has appropriately been called an electric eye. An improved device for the same purpose is the electric tripod, which was also invented by Branly. This consists of a plate of brass mounted on three steel feet which rest on a polished steel plate. When this apparatus is inserted in an electric circuit the current is interrupted by the imperfect contact between the feet of the tripod and the steel plate, but the current flows when an electric spark is discharged.

Instead of a galvanometer, an electro-magnet may be employed to detect the current. A piece of iron is mounted on an axis in such a manner that when attracted by the magnet it forces a point against a moving band of paper, as in the Morse recorder sometimes used in telegraphy. The passage of a spark at the sending station causes the coherer at the receiving station to allow a current to pass through the coils of the electro-magnet. The iron armature is immediately attracted and presses the writing point on the paper, making a dot, and the shock of the armature against its stop suffices to "decohere" the coherer and break the circuit. Or the writing point and the moving paper may be omitted, and the message received by ear by means of the shocks of the armature against its stop.

The coherer or radio-conductor may be employed, in a similar way, to determine any other effect of the electric current, as well as the deflection of a galvanometer or the attraction of an armature. Electric lamps and Geissler tubes can be caused to glow, Roentgen rays can be produced, various substances ignited or exploded, weights raised by electro-magnets, holes bored by electric drills, etc., at the will of a distant operator. Sensational effects have already been produced in theaters in this way. If several electrical circuits, each of which is arranged for the production of a single effect and is provided with its own coherer, are placed at the receiving station, a single spark at the sending station will operate them all at once. Still more complex effects can be produced by operating one circuit from the distant station and causing the first circuit to operate a second, the second a third, and so on. Even if only a single effect is desired this is best produced by means of a relay and not by the direct current through the coherer.

All such mechanical effects can be produced at distances of more than 100 miles, and they can be followed, and, so to speak, observed from the sending station by means of a new invention of Branly's. At the receiving station, where no human operator need be placed, is a mechanism which under the influence of a series of sparks produced at suitable intervals at the sending or operating station, brings about a series of mechanical and other effects, mutually dependent or independent, as desired. If independent these effects can be produced in any order desired but if dependent they follow each other in a certain definite order or its reverse.

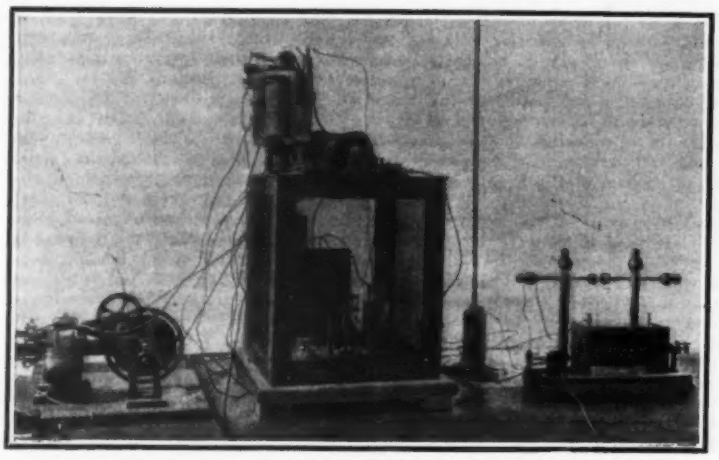


FIG. 1.—RECEIVING STATION WITH AUTOMATIC WIRELESS SENDER FOR RETURN MESSAGES.

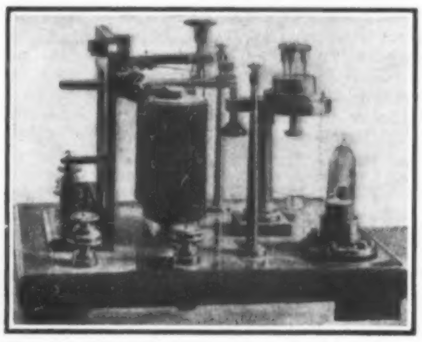


FIG. 2.—BRANLY'S TRIPOD RECEIVER WITH SOUNDER.

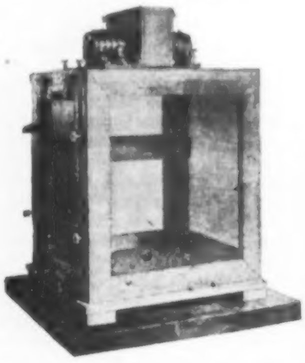


FIG. 3.—DISTRIBUTING SHAFT DRIVEN BY CLOCKWORK.

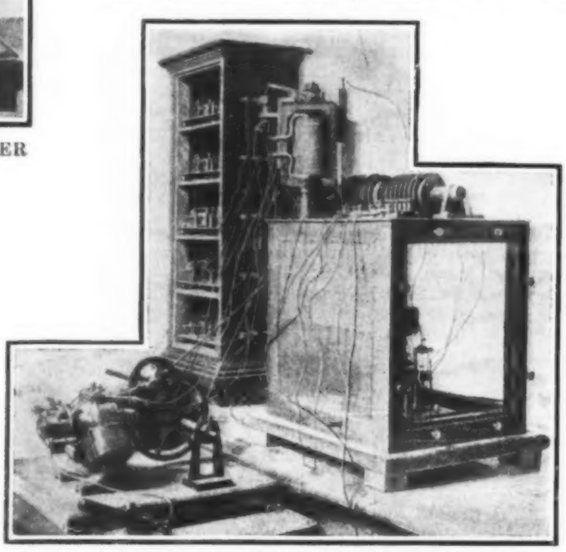


FIG. 4.—APPARATUS WITH DISTRIBUTING SHAFT DRIVEN BY ELECTRIC MOTOR.

For the purpose of enabling the distant operator to follow and control these effects as surely as if they took place before his eyes the receiving station is furnished with a slowly rotating horizontal steel shaft, called a distributing shaft. In Branly's first apparatus, shown in Fig. 3, this shaft was driven by the clockwork attached to the left side of the case, which supported the distributing shaft. In the newer apparatus, shown in Fig. 4, the clockwork is replaced by an electric motor, which can be started and stopped by wireless impulses from the operating station. On the shaft are a number of metal disks, insulated from each other, each of which serves to open and close the circuit corresponding to a particular effect, by means of a projection on the disk which makes contact with a metal spring during part of each revolution. The motor is shown in the left foreground of the illustration (Fig. 4). It is connected by a belt with the distributing shaft on top of the glass case which contains the various coherers and their accessories. The cabinet at the back contains the corresponding relays.

The projections on the rotating disks are so arranged that no two of them are in contact with their springs at the same time. Each contact lasts several seconds, during which the corresponding coherer or radio conductor is connected with its battery, relay, and decohering magnet and knocker, but the circuit is, in general, broken by the yet inactive radio-conductor. If during this interval a spark passes at the operating station the electric waves, traveling through space with the speed of light, immediately close the circuit through the radio-conductor, and therefore cause the relay to close the secondary circuit and produce the desired effect. If this effect is the lighting of a bank of electric lamps the lamps continue to glow until they are extinguished by another spark produced at the operating station after one or any number of revo-

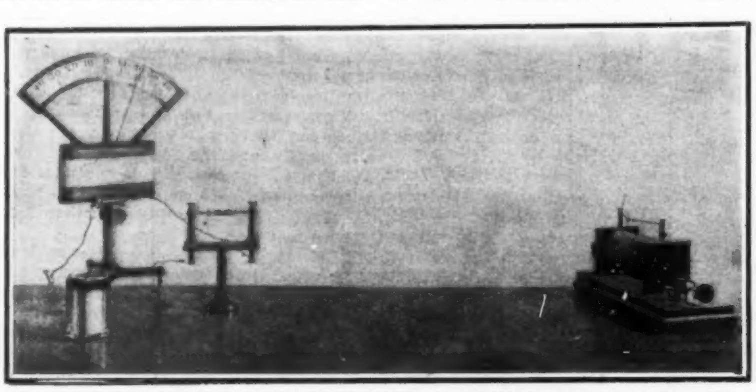


FIG. 5.—FUNDAMENTAL EXPERIMENT IN WIRELESS TELEGRAPHY.

FIG. 6.—RECORD ON OPERATOR'S TAPE WITH AND WITHOUT DASHES INDICATING PRODUCTION OF SPECIAL EFFECTS.

lutions of the distributing shaft and during the fraction of a revolution when the same disk is again in contact with its spring. As each disk determines a particular effect (and its opposite) four disks suffice, for example, to fire a pistol, start and stop an electric fan, light and extinguish a bank of lamps, and operate an electro-magnet which lifts and drops a cannon ball, as illustrated in Figs. 7*a* and *b*. Any other four possible effects may be similarly combined, for example the different operations of a machine tool which may thus be controlled by a distant and invisible operator.

During the fraction of a revolution in which it is possible to produce one effect no other can be produced because all the other circuits are open. The distant operator, however, knows at once whether the desired effect is actually produced or not, for the receiving station automatically sends him a wireless message which is impressed on the tape of a Morse recording apparatus before his eyes. This is effected by means of a supplementary series of disks on the distributing shaft.

The first of these supplementary disks bears (in the case of an apparatus for the production of four effects) five series of projections. These series are separated by approximately equal intervals and consist respectively of 1, 2, 3, 4, and 5 projections or teeth. As each tooth touches the contact spring it momentarily closes the circuit of the induction coil shown on the right of Fig. 1, thus producing a spark and an electric wave which travels to the operating station, and is recorded on the tape as a dot. Hence the tape presents the appearance shown in the upper part of Fig. 6, the distance between successive groups of dots being about four inches.

The interval between the single dot and the double dot may be used (for example) for firing the pistol but for no other effect. The second interval is available for the electric fan, the third for the lamps, and the fourth for the magnet and cannon ball. During each of these intervals one, and only one, of the principal disks is in contact with its spring, but all the circuits are open while each group of return signals and dots is being made. The interval between the group of five dots and the succeeding single dot is available only for stopping the electric motor which drives the distributing shaft. The motor may be started at any instant. Then there are four other disks and contact springs, one for each of the special effects. Each of these disks bears a single tooth which produces a short series of sparks and return waves, and a dash on the operator's tape, once in every revolution so long, and only so long, as the corresponding effect continues. Consequently, as long as the dash is repeated in the proper space between the groups of dots the operator knows that the given effect is being produced. The dashes are easily distinguished from the dots by their greater length, as is illustrated in the lower part of Fig. 6.

This ingenious apparatus for producing mechanical effects at a distance by wireless transmission may be utilized for many purposes. For example, by employing the disks, one for each letter of the alphabet, a wireless printing telegraph might be constructed which would reproduce the message in ordinary type. Steam engines could be started and stopped, railway trains dispatched and arrested, lighthouse lamps lighted and extinguished, unmanned airships and submarines guided, torpedoes launched and steered, and mines exploded by operators at a distance. Interference by sparks of extraneous origin can be guarded against without difficulty. Dr. Branly is working diligently to perfect the apparatus and make it available for technical uses.—Illustrirte Zeitung.

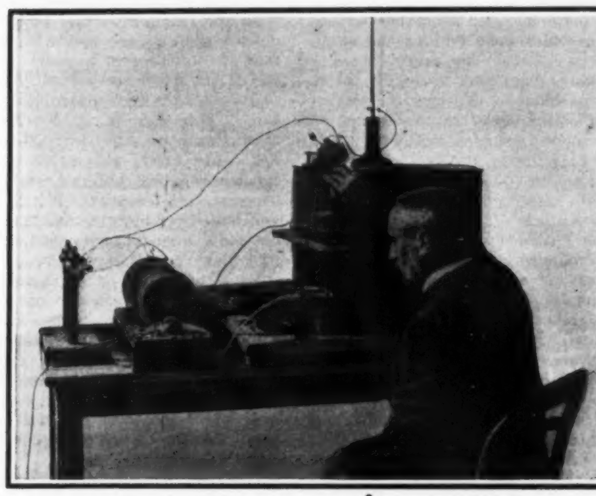
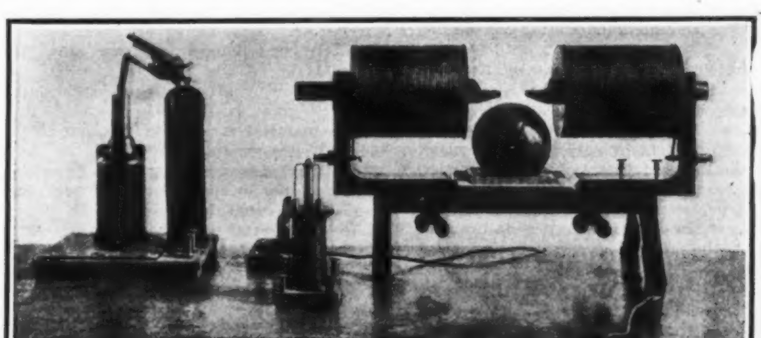
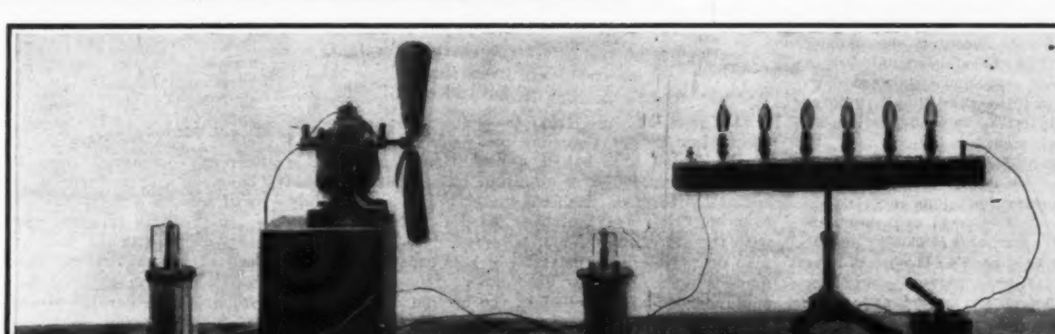


FIG. 9.—OPERATOR SENDING IMPULSES WHICH PRODUCE DESIRED EFFECTS. READING THE AUTOMATIC RETURN MESSAGE.





FIGS. 7*a* AND *b*.—ELECTRIC FAN, LAMP BANK, PISTOL AND LIFTING MAGNET, ARRANGED FOR SUCCESSIVE OPERATION FROM A DISTANCE.

ARTIFICIAL FIREPROOF STONES.

MATERIALS capable of being exposed for long periods of time to the action of great heat are designated as absolutely fireproof substances when they undergo no alteration in consequence of such action. In view of the enormous development of the mechanical arts in the present day, necessitating the frequent employment of very high temperatures, the manufacture of really fireproof substances has acquired such importance that it has not only grown into an independent industry, but has become subdivided into various branches. Thus there are factories which give their exclusive attention to the manufacture of fireproof bricks, others whose special line is the production of fireproof crucibles, etc.

Of late the term fireproof has undergone considerable restriction, and this restriction dates from the time when the heat developed by the electric arc began to be employed for melting or fusing certain substances. This application of electricity has led to the introduction of the electric furnace, now so extensively used in the production of aluminium, magnesium, carborundum, calcium carbide, etc.

The heat of the electric arc is so great that platinum, which hitherto could be melted only in the flame of the oxyhydrogen blowpipe, can be made to boil and be vaporized by it. Substances which cannot be fused in our ordinary furnaces, such as alumina and magnesia, can be melted like glass in the electric furnace. There are, it is true, certain substances, such as carbon and osmium, which it is at present impossible to melt even with electricity, but it seems highly probable that electric currents will yet be produced capable of melting all known bodies, without exception.

Fireproof Material for Electric Furnaces.—At present the material of which electric furnaces are constructed consists exclusively of carbon in the form either of mineral graphite or of gas carbon, the substance deposited in the arches of gas retorts. Sometimes carbon in the form of coke is used; ordinary charcoal is not employed, being more expensive than the other kinds of carbon mentioned.

Carbon intended for use in the construction of electric furnaces is prepared by reducing graphite or coke to a fine powder and making the latter into a plastic paste with the aid of a binding agent. A structure of fireproof stones is then lined with this mass. This structure is usually made in the form of a crucible in which the substances to be melted are exposed to the action of the electric arc. Very thin starch paste has been found to be the best binding agent for the carbon powder; it is decomposed when the furnace is heated, nothing remaining but pure carbon.

The main requirement in an electric furnace is that the treated material should be protected against cooling from the outside; the carbon lining must therefore have considerable thickness, so that the carbon itself acts as an insulator. Fine quartz sand is generally pressed down between the walling and the carbon crucible. When the construction of the furnace is completed the carbon mass must be left to become thoroughly dry and the furnace then carefuly heated with charcoal to remove the last traces of moisture and to decompose the starch. Not till then should the furnace be used for electrical purposes.

Before the graphite or coke is used in making the carbon lining it must be tested to ascertain its adaptability for this purpose. Many kinds of graphite and the coke derived from various kinds of coal contain a large admixture of mineral matters, such as iron oxide, compounds of lime and magnesia, and silicic acid, so that in the heat of the electric arc these substances will enter into chemical action with the carbon, carbide compounds will be formed in the mass, and the latter be liable to crack when the furnace is cooled.

The simplest way of testing the material is to grind a small sample fine and with the aid of the starch paste to make it into cylindrical rods similar to those used in electric arc lamps. These rods are used as the electrodes of the electric arc. If the material is suitable for its purpose, the rods will be gradually consumed without leaving any residue; if, on the other hand, it contains large quantities of mineral sub-

stances, pieces of slag will be formed, in which case the graphite or coke must be purified. This is done by treating the powdered material with concentrated nitric acid. The iron oxides, the lime, and the magnesia will be dissolved and may then be removed by washing the powder with water. To remove any silicic acid still remaining, the mass must be boiled with strong soda lye and again washed with water.

Fireproof Substances for Furnaces.—Fireproof materials of varying capacity for resisting the action of high temperatures are required for these furnaces. In constructing the walls of furnaces for boilers and other fireplaces in which fire has to be kept up for a considerable time, the material used must be capable of completely enduring white heat and at the same time be strong enough to resist so far as possible the mechanical injury arising from the throwing in of coal. It must also have sufficient capacity for expansion not to crack in consequence of rapid heating or cooling. These requirements seem to be met by the so-called "chamotte" fire clay.

Many furnaces, however, are of such a nature that the material of which they are constructed is exposed to entirely different conditions. This is the case, for instance, with material intended for the erection of blast furnaces for the smelting of iron ores. Such material must be capable of resisting for long periods of time, for months and years, the action of the highest temperatures, temperatures often exceeding 2,000 deg. C. It must also be unaffected by the chemical action of the melting masses in the furnace, ores, fluxes, etc. As there is no known substance which completely meets these requirements, the parts of the blast furnaces most exposed to these chemical influences must be renewed from time to time.

Chamotte.—This material is essentially a fireproof clay. To test the adaptability of a clay for the preparation of chamotte, it is usually sufficient to expose it to the temperature prevailing in the sharp fire compartment of a porcelain oven. Bodies with sharp edges and corners are made from the clay and placed in the sharp fire of one of these ovens. If, after being exposed to the fire for some time, the body shows no sign of fusing or sintering, the clay may be regarded fireproof. The clay must not contain any lime; the latter substance would not, it is true, impair the fireproof property of the clay, but it would render it useless for the manufacture of fireproof masses owing to the alteration which it would undergo when the clay is stored in the open air.

When the clay has satisfactorily undergone this test, it has only to be shaped into lumps the size of a man's fist and baked without interruption in a shaft furnace. The baked clay is finally converted into fine powder by grinding in a crushing mill or disintegrator and then constitutes the mass known as "chamotte."

The preparation of chamotte powder in the way we have described involves considerable expense; chamotte factories therefore endeavor, as far as possible, to procure ready chamotte material for further treatment. Raw material is to be found in various waste products, such as fragments of broken porcelain utensils, stoneware, bricks from worn-out furnaces, fragments of saggers in which porcelain is baked, etc. All these substances, as will be seen, consist of highly-baked fireproof clay.

Chamotte is made from these substances by grinding the fragments to powder and mixing the latter with fireproof clay, adding suitable quantities of sand, which must also consist of fireproof matter (quartzose sand), to the mass. As this mass is very lean, i.e., does not possess much binding power, the molding of the fireproof chamotte stones must be performed with great care.

The shaping process is best done in iron molds. These are completely filled with the chamotte mass and the material in the forms is then subjected to a powerful pressure in a press. The chamotte materials are prepared usually in forms so constructed that the masses need not be broken or cut up into smaller pieces before being used in the building of smelting or other furnaces. They are therefore molded into prism-shaped bricks. Joined together, they can be made into an arch; placed side by side, they will form a circular cylinder; in this latter way they are used in the erection of shaft furnaces.

The baking of chamotte bricks must be done with extreme care in order that the larger pieces may not become warped and that no refuse may result. In building furnaces with chamotte stones ordinary chamotte powder is used for mortar, and it is very important that the stones should be placed so close beside or above one another that only very narrow seams are visible, which seams are carefully coated over with chamotte powder stirred into a thick paste with water, so that the entire cavity of the furnace is surrounded with the fireproof mass.

Fireproof Masses for Smelting Furnaces.—Before the process of making artificial fireproof material was discovered, steatite, a substance consisting mainly of silicates of magnesia, was generally used. Steatite in its normal state possesses but little hardness, but it can be rendered very hard by heating it to a white heat. In addition to steatite, which is not often found in sufficiently large quantities for making ashlars, quartz is frequently used in building absolutely fireproof furnaces.

Quartz or quartzite consists of almost entirely pure silicic acid, which is completely insoluble in the heat of our furnaces and resists chemical action very well with the exception of that of dissolving alkalies.

In England, where blast furnaces have been in operation for long periods, stone from the dinas rock in the Vale of Neath, near Swansea in South Wales, is preferred for blast and welding furnaces. This rock consists of pure quartzite.

Chemistry has provided an artificial mass not inferior to dinas rock in its capacity for resisting the action of heat, and the preparation of which does not involve the excessive labor necessary for making ashlars from quartzite. These artificially-prepared masses are also termed dinas stones, and the term is now generally understood to denote this material, a material at once hard, fireproof, and rich in silicic acid.

Dinas Material.—The substance from which artificial dinas masses are prepared consists likewise of silicic acid, and it is used either in the form of pieces of pure quartz, such as are met with in primitive rock, or in that of flint, present in many localities, particularly on the coasts at the foot of chalk cliffs.

Quartz and flint must be disintegrated into coarse sand. This can be done without applying excessive force if the material is suddenly chilled before grinding. The stones are raised to a red heat in a shaft furnace and then plunged while red-hot into cold water. They are rendered very brittle by this sudden chilling and show innumerable small cracks internally, so that one blow from a hammer often suffices to shatter them into many small fragments.

By grinding in a stamping or crushing mill, we obtain a coarse-grained, very sharp edged sand. It is advisable to continue the grinding process till the grains are reduced to the size of two to three millimeters. To make a moldable mass from this sand, one part by weight of burnt lime is used to 100 parts of sand. The lime must be slaked immediately before use, and mixed with only so much water as is absolutely necessary, in order that the lime-milk may mix with the quartzose sand. The mixing must be performed in a machine, in order that every grain of quartz may be surrounded with an envelope of lime.

The mass obtained in this way is only slightly ductile or plastic. To render it plastic, it should be vigorously pressed down into the iron molds and then, while in these forms subjected to as great a pressure as possible. The molded dinas stones are carefully dried by artificial heat and then put into the baking oven, the latter being so constructed that the material in it can be subjected to the most intense white heat. As soon as the oven has been sufficiently heated to produce this condition, every opening in it is closed and it is left to cool gradually by itself till the contents have been reduced to the normal temperature, which may take a week with a large oven.

It is indispensable that the stones should be cooled in the manner described, for they are best protected against fracture by this process. If the dinas stone is taken hot from the oven and allowed to cool rapidly in the open air, a peculiar crackling sound is heard, which always accompanies the formation of cracks in the mass, and the stone then generally crumbles into a number of fragments of various sizes. The occasional breaking of a stone cannot altogether be prevented; the broken stones are ground up and the resulting coarse powder used as dinas mortar for binding stones together.

When quartz and lime are heated to a white heat, the silicic acid and lime react upon each other in such a way that an uncommonly refractory silicate of lime is formed, which, as a half-fused sintered mass, unites the individual quartz grains into a tolerably firm mass, becoming harder the longer it is exposed to the action of a very high temperature. The composition of dinas stones may be varied somewhat by different admixtures, but these must always be of such a nature that only silicates with the highest possible fusing point are formed.

A dinas mass compounded in this way is obtained, according to a recipe due to Nehse, by dry mixing quartz sand with kaolin and caustic lime slaked to a powder. The mixture is lightly moistened immediately before molding, then pressed into the form and subjected to high pressure. Nehse's recipe gives:

Quartz sand	100	parts by weight.
Burnt lime	7 to 8	" "
Kaolin	3 to 4	" "

The mass obtained from these ingredients is somewhat more plastic than one made of quartz and lime alone. When it is baked, a highly refractory double silicate, composed of aluminium silicate and calcium silicate is formed. Nehse's stones are also absolutely fireproof; they are, moreover, harder than those made with the aid of lime alone.

In preparing dinas material by this process, strongly-made wooden molds are used, open at the top and with a number of holes drilled in the bottom. The bottom is provided with four short feet in order that it may not come into contact with the surface of the vessel in which the form is placed. The quartz sand is sprinkled with a solution containing about 5 per cent of calcium chloride or magnesium chloride, or a mixture of both salts, and pressed as firmly as possible into the forms. The forms are then placed in a vessel and the latter filled with a very weak solution of waterglass. The waterglass gradually penetrates through the openings in the bottom of the wooden forms and passes upward through the sand mass. Here, again, the calcium chloride or magnesium chloride combines with the waterglass and is transformed into calcium silicate or magnesium silicate and sodium chloride. When the sand mass is completely saturated it is tolerably hard by reason of the gelatinous nature of the freshly precipitated calcium silicate or magnesium silicate and may be carefully removed from the forms. It is left to dry thoroughly in the air and then baked in a strong heat. During this process the silicates lose all their moisture and firmly bind and sinter the particles of sand; the sodium chloride contained in the stones is entirely volatilized during the baking.

Material for Fireproof Crucibles.—The description which we have given of the nature of fireproof masses in general, and of chamotte and dinas stones in particular, will help to explain the composition of the material used in making crucibles. In addition to being fireproof, a mass suitable for making crucibles must be capable of enduring rapid changes of temperature without cracking and be so close in texture that the substances dissolved in the crucibles will not be absorbed by it.

Crucibles of Fireproof Clay.—Fireproof clay, with or without the admixture of chamotte, is therefore used in the preparation of masses for crucibles, as much sharp-edged quartz sand as possible being worked in, in order to obtain a sufficiently plastic mass, from which the crucibles are then molded, generally by hand. Apart from the fact that this method of molding is expensive and that crucibles of absolutely equal size can never be obtained by it, it is subject to the drawback that the mass is not firmly pressed together.

To make crucibles properly, it is absolutely necessary to use iron molds, in which the mass is stamped between the outer casing and the core and then tightly compressed by firmly pushing in the core.

When crucibles are made in this way their sides will always have the same thickness and the formation of bubbles and cavities in the crucible mass will be entirely prevented. The last-mentioned circumstance is of the greatest importance for the durability of the crucible. If a crucible, the sides or bottom of which contain one or more cavities, is exposed to a strong fire, it will immediately be destroyed, for the air in the cavities is so powerfully expanded by the glowing heat that the sides of the crucible are unable to resist the pressure and it will burst with a loud report.

Graphite Crucibles.—Graphite is a substance which is insoluble and may therefore be mixed with the fireproof clay mass of which crucibles are made. The admixture of graphite is attended with the advantage that the mass will not readily crack with sudden variations of temperature. Graphite is known to be a good conductor of heat, and consequently equilibrium between the inner and outer temperature of the crucible mass is reached far more rapidly when, for example, a white-hot crucible containing fused metal is removed from the furnace. As the surfaces of a graphite are much smoother than those of a clay crucible, the fused contents may be poured out without danger of any particles adhering to the sides, an important consideration in the preparation of alloys of precious metals.

Magnesia Crucibles.—Crucibles made of pure magnesia undergo no alteration even in the greatest heat; repeated exposure to white heat only increases their hardness and strength. They are therefore particularly adapted for melting nickel, cast steel, ferrous chrome, etc., and, moreover, possess the great advantage that no chemical reaction takes place between the material of the crucible and its fused contents. Since, however, only very pure magnesia possesses this property, great care must be exercised in the selection of the material for use in the manufacture of crucibles; the magnesite from which the magnesia is obtained must also be quite pure.

The magnesite must be ground very fine and lightly annealed to expel the carbonic acid. The greater part of the magnesia, about 80 per cent, is, however, exposed to the highest furnace heat attainable and thereby rendered as dense as possible. Eighty parts of the sharp-baked magnesia are now thoroughly combined with 20 parts of the slightly-baked magnesia, then mixed with only as much water as is necessary to form a thin paste to prevent the mass from falling to pieces, and molded into crucibles under great pressure in an iron form.

After pressing, the outer part of the form is removed and the crucible coated with a saturated solution of boric acid in water by means of a hair pencil. The solution is rapidly absorbed and the operation repeated several times in the case of large crucibles with thick sides. The crucibles are then left to dry in the air, carefully removed from the core of the mold, and baked in a flame furnace. By this process the crucibles will acquire a remarkable degree of strength.

In the high temperature to which the crucibles are exposed during the baking process, the boric acid absorbed by the crucible mass combines with the magnesia to form magnesium borate, which sinters and imparts considerable strength to the mass. The cost of manufacturing magnesia crucibles is rather high, but, nevertheless, they must be regarded as cheap when compared with others, since they can be used for an unlimited time with careful handling. Even when cracked they can be rendered serviceable again by coating the cracked surface with a boric acid solution, filling up the cracks with magnesia and reannealing.

By skillful use of the electric current it is even possible to make crucibles of extraordinary strength from melted magnesia. The following is the method of procedure employed by the Deutsche Gold- und Silberscheideanstalt: To a piece of carbon with a raised conical portion at the top in the shape of the crucible is fitted a tube, likewise made of carbon and having another larger piece of carbon covering it. This tube is filled with magnesia powder. If the upper and lower pieces of carbon are connected with the poles of a powerful dynamo, such an intense heat is developed by the conductivity resistance in the carbon tube that

the magnesia is dissolved and a crucible of melted magnesia is formed over the correspondingly shaped cone of the lower piece of carbon.

When the melting process is completed, the electric current is stopped and the crucible left to cool in the mold. Crucibles can be made from melted alumina by the same method. Fireproof bricks can be made from magnesia baked in a sharp fire in the same way as fireproof crucibles; they can be used where even the best chamotte is not sufficiently fireproof. As, however, we have in properly prepared dinas stones a material not inferior to magnesite stones in their capacity for resisting heat and at the same time much less expensive, it is probable that at present magnesite bricks will only be used for the lining of furnaces in quite exceptional circumstances.—Translated from the Deutsche Goldschmiede Zeitung.

THE VARIED USES OF CYPRESS.*

AMERICA is still a land of homes. The multiplication of apartment houses, flats, and family hotels may call forth the dismal croak of the pessimist, but the fact remains that the great mass of intelligent and industrious American people hope and plan for real homes of their own some day—single houses with plots of green and beds of flowers, away from the frenzied turmoil of crowded city streets.

The constantly increasing price of building materials has not stifled this desire. It has, however, caused the prospective house builder to study the whole situation more carefully, to learn the values of the different woods more intimately, to make himself so thoroughly familiar with prices and materials that he shall not be at the mercy of either architect or contractor.

Among the things he has learned of late is the fact that cypress contains possibilities which can be realized at a much less expense than is the case with other woods which have been considered almost indispensable for certain purposes. It is little less than remarkable that cypress has been so long neglected in some parts of the country. It is one of the most adaptable and interesting woods. Its immunity from the ravages of time has become a matter of recorded history. The doors of St. Peter's Cathedral at Rome, placed in position by Constantine, swung to and fro for 1,100 years, and, when finally they gave place to doors of brass, were found to be practically as sound as when first hung on their ancient hinges.

Cypress resists the attacks of air, water, and even, to a large extent, fire itself, says Arthur T. Bronson in a recent issue of Suburban Life. It seems to contain a natural preservative. Its strange quality of being practically unaffected by decay is attributed to the presence of an unusual amount of resin; on the other hand, it is free from pitch, so that, when attacked by fire, it smolders slowly and seldom breaks into flame. This matter of durability becomes a most vital one in the eyes of the builder in these piping times of unprecedented prices for building materials and labor. It means insurance against repairs for many years to come.

It is important that the man who is building a home for himself, his children and perhaps for his children's children, too, shall have an accurate knowledge regarding the various building materials, including the different varieties of lumber.

LIFE OF SHINGLES.

Here is believed to be a fair estimate of the life of shingles cut from various woods:

Spruce shingles	5 to 7 years
Cedar shingles	12 to 15 years
Sawed pine shingles	16 to 20 years
Cypress shingles	30 to 50 years

This is called a fair estimate, because there are cases on record where cypress shingles have been found in very good condition after nearly a century of use. This is due, of course, to the comparative imperviousness of cypress to decay, which also accounts for the fact that almost all wooden gutters are of cypress, and considered to be good for an indefinite period. Even these qualities, however, would not be sufficient if certain other defects, such as warping, shrinking and cracking existed. Fortunately, the natural elasticity of cypress prevents any of these defects.

The question naturally arises, why, if cypress is so little affected by the elements, it is not adapted to exterior work of every description. As a matter of fact, cypress clap-boards are coming more and more into popular use. It is not employed so much for framework because there are other woods which can be used and which cost somewhat less, and yet the fire-resisting qualities of cypress make it of exceptional value even for that purpose.

An exceedingly artistic effect can be secured by shingling the house all over with cypress, and ignoring the claims of the painter, allowing it to gradually take on the remarkably attractive "weather finish," which cypress assumes when touched only by Nature's brush. If, however, clap-boards and paint are decided upon, the pigments can be applied smoothly and economically, and the paint will not peel off—a point which is worthy of more than casual notice. Moreover, its ability to resist decay gives it a special value in any place where climbing vines are trained over the house.

Having planned the exterior of his house, with a thought of permanency and a hope of postponing the unpleasant necessity of making repairs as long as possible, our home builder turns with even more enthusiasm to the construction and finish of the interior, and especially of those apartments with which he and his family are to have an intimate acquaintance in the years to come. Here he will find himself at a point where three considerations focus—the first tradition, the second economy, and the third good taste. Tradition will urge the claims of oak, hard pine, and maple, as best adapted to artistic and durable finish. Pine and spruce will speak for economy and paint. Good taste may be satisfied with any of these woods, properly used, but in many cases economy will outweigh tradition, while good taste will not be satisfied with paint. The result will be the use of cypress, which is as beautiful as the traditionary woods and almost as cheap as those chosen by economy.

* Carpentry and Building.

THE GRAIN OF CYPRESS.

The beauty of any natural finished wood lies, of course, in its grain, and the grain of cypress expresses more than beauty; it expresses character as well, and gives a striking dignity and individuality to a room. At the same time a great variety of different effects can be secured. The wood is beautifully grained, shading from the rich yellow of quartered oak to a dark brown almost as deep as black walnut.

With the growing appreciation of the beauty of fine woods, there is an inclination to use less plaster and paper and a greater amount of natural finish, with panels and simple decorations—a method of treatment which conduces to an atmosphere of refinement and artistic cultivation. However, a wood like cypress, which requires but a modicum of care and attention, is of no little advantage from the standpoint of household economy.

There is a curious fact worth noticing in this connection. It pertains to a matter not usually discussed in polite society, but yet essentially important. It is the fact that bugs and vermin have a positive dislike for cypress. It is pretty safe to state that there will be an absence of these visitors when cypress is used.

It is interesting to examine into the relative cost of cypress and other woods which have been more commonly employed. Oak, which is probably the most popular wood for hardwood finish among people whose purses are long enough to allow them to use it, costs a good two-thirds more than cypress. Walnut, cherry, and butternut occupy the same relative position as regards the matter of price. Whitewood costs five per cent more than cypress, and yet has no beauty of grain whatever. Hard pine costs five per cent less than cypress, but has very few of its advantages and is used chiefly for finish work in kitchen and pantry.

Cypress shingles may run a trifle higher in price than those of cedar, but as a rule they wear longer.

In figuring exterior work, it will be found that cypress and spruce clap-boards cost about the same. Many cypress clapboards are rabbeted, giving tighter joints.

There is just one note of warning which must be remembered when cypress is under consideration. All woods used in interior work must be thoroughly kiln dried. For exterior work it must be thoroughly air dried. This matter is of the greatest importance if satisfactory results are to be secured. All that is said here in regard to cypress is said with the assumption that the wood is properly prepared before being used in any manner.

As a summing up of the matter, it may be said with truth that there is no wood to be obtained at any cost which is adapted to so wide a variety of purposes as cypress.

SIR J. CRICHTON BROWNE ON AMBIDEXTERITY.

A FRIDAY evening lecture at the Royal Institution was given recently by Sir James Crichton Browne, whose subject was "Dexterity and the Bend Sinister." He said that during the last 2,000 years there had been innumerable eruptions of ambidextral enthusiasm, and some five years ago a new crusade on behalf of ambidexterity had been started. He held, however, that on the large scale ambidexterity was impossible and undesirable, that it was by the superior skill of his right hand that man had gotten himself the victory, and that to try to undo his dextral pre-eminence was simply to fly in the face of evolution.

Right-handedness was a very old story; it was plainly discernible in the art of Greece, Assyria, and Egypt, glimpses of it could be found among our ancestors in the Bronze Age and in Palæolithic times, and some observers had detected foreshadowings of it even among the lower animals. All nations, tribes, and races, civilized and savage, had in all times preferentially used not only one, but the same, hand, and it was impossible to point to any civilized race manifesting any degree of either-handedess; the statement that the Japanese were by law and practice ambidextrous, he could say on the authority of Baron Komura, was without foundation. It was doubtful, indeed, whether, strictly speaking, complete ambidexterity existed in any fully developed and civilized human beings, though sometimes very close approximations to it occurred; but among microcephalic idiots, in whom the small-headedness was due to arrested development, left-handedness and ambidexterity had been found to reach a proportion as high as 50 per cent. The source of right-handedness was much deeper than voluntary selection, and must be sought in anatomical configuration—in the structure and organization of the brain that initiated, directed, and controlled all voluntary movements. The brain had two hemispheres, of which the right presided over the left side of the body, and the left over the right side, and it was clear that functional differences in the two hands were in some way connected with differences in the two hemispheres—differences not of weight or blood supply, as had been suggested by some inquirers, but of convolutional development. Study of the speech center in the third frontal or Broca's convolution had thrown a flood of light on the subject of right-handedness, for it had shown that damage to this convolution in the left hemisphere deprived the right-handed man of speech, but left the left-handed man with speech unimpaired, while in the left-handed man the contrary held good.

Here, then, there was one-sidedness of the brain, assuredly not due to use and wont, or to any acquired habit or mechanical advantage. But the hand and arm centers in the brain were intimately linked with the speech centers, and therefore it was only logical to infer that the preferential use of the right arm and hand in voluntary movements was also due to the leading part taken by the left hemisphere. We could not, he believed, get rid of our righthandedness, try how we might. It was woven in the brain; to change the pattern the tissues must be unraveled. Ambidextral culture, useful enough in respect of some few special movements in some few specially employed persons, must in the large scale tend to confusion; and pushed toward that consummation which its ardent apostles said was so devoutly to be wished for, when the two hands would be able to write on two different subjects at the same time, it must involve the enormous enlargement of our already overgrown lunatic asylums.

REMARKABLE EYES OF OLD MEN AND PRIMITIVE PEOPLES.

THE human eye is said to be a rather ill-contrived piece of mechanism. A celebrated German physicist is reported to have remarked that if an artisan were to make for him a piece of apparatus so poorly adapted to its purpose he would not accept it. Biographers have, however, preserved the names of a considerable number of persons from the remote and more recent past whose mental faculties were unimpaired at fourscore and beyond, though it is not often that this could be affirmed of their sight. The last chapter of Deuteronomy informs us that Moses was "an hundred and twenty years old; his eye was not dim nor his natural force abated." There is nothing incredible in this record, for similar instances are not very rare. A colored woman died in Philadelphia in January, 1906, who seemed to have pretty clear recollections of Washington at Valley Forge. Her friends claimed for her the age of one hundred and thirty-five. A writer in a recent issue of the Monthly Review mentions a number of Kaffirs still living in 1885 who professed to have taken part in a battle in 1818. Burton made the acquaintance of a chief, whom he described in 1857 as a very old man; but eighteen years later Cameron found him still ruling his people and very little changed in appearance. While Humboldt was in Lima an Indian died there at the age of one hundred and forty-three. "Blindness overtook him at the age of one hundred and thirty, but till that misfortune he used to walk three or four leagues daily." He also declares that during his five years' residence in Mexico and South America he saw no person afflicted with bodily disease or even with squinting. Tschudi says that one hundred and thirty years "with unimpaired faculties" is not at all uncommon in Peru. These references are doubtless to natives; and what is true of the so-called lower races does not necessarily hold good of the more advanced peoples. Among the more recent cases that are thoroughly authenticated are the Hon. David Work, of Fredericton, N. B., who died in 1905, nearly one hundred and two years old. He was a man of mark in his community, and mentally and physically sound almost to the end. The celebrated French chemist, Chevreul, who died in Paris in 1889, was about a year older. John Wesley at eighty-five writes that he is "not quite so agile as he was in times past and his sight is a little decayed." Most persons, unless their observations have been very limited, have met individuals who lived close upon five score years or even beyond. Several Roman writers likewise give 120 years as the utmost limit of human life. Sight is pre-eminently the civilizing sense; upon it all progress depends, or, as Oken expresses it, "Sight is the light sense. Through it we become acquainted with universal relations, this being *reason*. Without the eye there would be no reason." The same thought is expressed in the Sermon on the Mount: "The lamp of the body is the eye. If your eye is unclouded your whole body will be lighted up; but if your eye be diseased your whole body will be dark." Not only painting, sculpture, and architecture are dependent upon sight, but language also as soon as it becomes the transmitter of experience, whether inner or outer, from age to age. Those peoples that never cultivate speech beyond the point where it is perceived by the ear alone, never advance farther than the primitive stage. But as soon as speech becomes cognizable by the sight, it can be employed to fix the experience and the accumulated knowledge of each generation. It is by means of our eyesight that we are able to learn the thoughts and, to some extent, the feelings of the people of the most distant ages and the most remote regions, almost as well as those of our intimate friends. Yet when we remember that man has left intelligible traces upon the earth, dating back at least seven thousand years, and compare their testimony with the world, say three hundred years ago, we are not conscious of a great advance either intellectually or socially. It is evident therefore, that important as sight is to man, something more is needed to make him progressive. As soon as the mind becomes fossilized by tradition all advance

ceases. If, on the other hand, we compare the world about A. D. 1600 with its condition at the present day, we are constrained to marvel at the advance that has been made. In fact it is not putting the case too strong to say that if by progress we mean man's power over matter, it has been greater during the last fifty years than during all the preceding time of his abode upon the earth. No more striking example of the stationary condition of mankind in certain relations exists than that furnished by artificial lighting. The situation in 1800 was virtually the same that had existed from the earliest times. Torches were used out-of-doors and lamps indoors. Many of the latter found in Grecian and Roman tombs served their purpose just as well as some of those used within the memory of men now living. Friction matches did not become general until about the middle of the last century. It is sometimes said in a tone of deprecation that as the realm of science increases that of poetry diminishes. Yet the fact is that the appreciation of the beauties of natural scenery has advanced with the careful study of nature. There may not be a realized connection, for poets are rarely scientists; albeit both have often been equally close observers, even if not found in each other's company or united in the same person. Few men have written more appreciatively or more sympathetically of the beauty and grandeur of natural scenery than geologists not a few; and geology is among the most modern of the sciences. The botanist who sees vegetation not only with his corporeal eye, but with his mind as well, derives a keener enjoyment from the beauties of vegetable life than does he who can not see beneath the surface; who has no conception of the forces that make plant life what it is.—Popular Science Monthly.

MODERN METHODS OF PHOTOMETRY.

By Victor Quittner.

As light is a subjective or physiological, rather than an objective or physical phenomenon, and as there is no known substance in which sensitiveness to light, as a function of color or wave length, obeys exactly the law which governs the human eye, it follows that the eye must be the final judge in the comparison of lights of different colors, though the comparison may

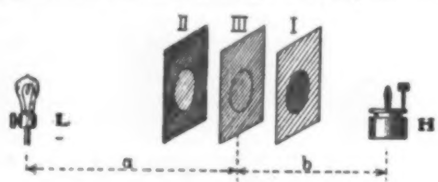


Fig. 1.—BUNSEN'S GREASE SPOT PHOTOMETER.

be made more accurate and certain by the employment of apparatus. Even in comparing lights of the same color optical photometers are commonly employed, though it is possible to make the comparison by purely objective methods based on the properties of selenium or silver salts.

In either case the unit of measurement must first be determined. In Germany, the standard candle formerly employed has now been generally replaced by the Hefner standard acetylene lamp of prescribed dimensions and a flame 40 millimeters high. The horizontal radiation of such a lamp is the unit of light emission. It is called a Hefner candle power and designated by the symbol HK.

All photometric methods and apparatus are based on the law that the illumination of a surface is proportional to the power of the source of light divided by the square of its distance from the surface.

One of the oldest instruments, which is still often used, is Bunsen's grease spot photometer, the principle of which is illustrated by Fig. 1. As the application of grease to white paper makes the paper more translucent, a grease spot appears brighter than the surrounding paper when seen by transmitted light, but darker when seen by reflected light. Hence if the spotted paper is placed between two lamps the greased part will appear as a dark spot when viewed from the side of the lamp which produces the stronger illumination at the position of the paper and as a light spot when viewed from the opposite side. Thus, when the paper is placed at *I* (Fig. 1) near the Hefner lamp, *H*, the side toward that lamp shows a dark spot, but this changes into a bright spot when the paper is moved to *II*, where it is more strongly illuminated from the back, and at an intermediate point, *III*, the spot vanishes. If the grease spot were perfectly transparent and the ungreased paper neither transmitted nor absorbed any light, the disappearance of the spot

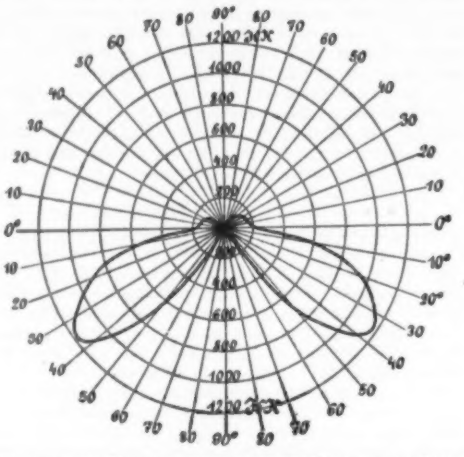


Fig. 5.—CURVE OF DISTRIBUTION OF LIGHT (MEASURED IN HEFNER CANDLES) OF 10 AMPERE DIRECT CURRENT ARC LAMP.

would prove that at *III* the paper was equally illuminated by the two lamps. Hence the powers of the lamps would be directly proportional to the squares of their distances from *III*, that is, the candle-power of the incandescent lamp *I* would be expressed by a^2/b^2 HK.

In this case the spot would vanish from the other

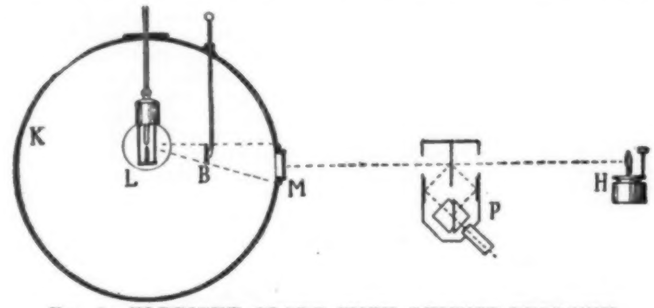


Fig. 6.—ULBRICHT GLOBE WITH LUMMER-BRODHUN PHOTOMETER.

side of the paper also at *III*, but in fact the paper must be moved a little, to obliterate the spot from the other side. If a^1 and b^1 are the distances from this new position to the lamps, the correct candle power of *L* is expressed by aa^1/bb^1 HK. Or the lamp to be measured and the standard may successively be placed in front

Fig. 7.—EXTERIOR VIEW OF ULBRICHT GLOBE.

of the paper and compared with a third lamp behind the paper which is viewed from the front in both measurements.

In the photometer of Lummer and Brodhun, which is now very extensively used, the grease spot is replaced by two rectangular glass prisms (*A*, *B*, Fig. 2). The oblique face of one prism is plane; that of the other is spherical with the exception of the central part *l m*, which is plane and pressed into optical contact with the first prism. Hence light from the lamp *L* passes through the central part of the two prisms,

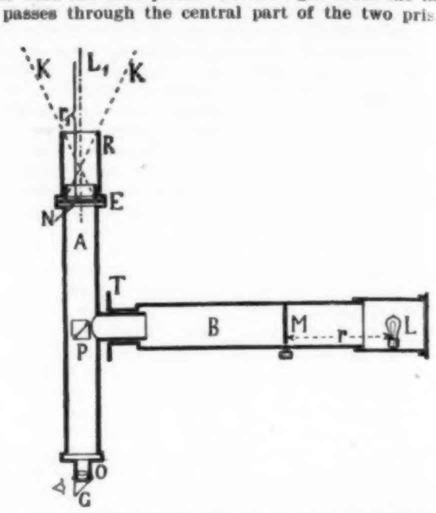


Fig. 8.—WEBER'S PORTABLE PHOTOMETER.

as if they formed a single block of glass, to the lens *q* and the eye *a*, opposite that lamp, but the rays that fall outside the contact plane *l m* are deviated by total reflection and do not reach the lens. Hence if the lamp *L* alone is lighted the eye looking through the lens sees a round bright spot on a dark field. Fig. 3 shows the appearance and the course of the rays. On

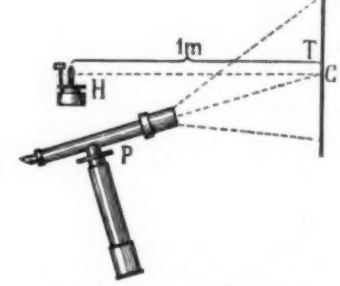
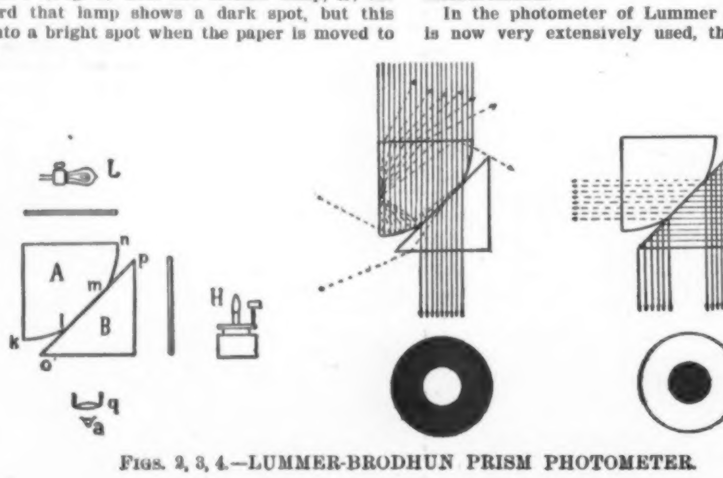


Fig. 10.—STANDARDIZING WEBER'S PHOTOMETER.

the other hand, if only the lamp *H*, to the right of the line of vision, is lighted, the outer parts of the beam will be totally reflected to the lens and the eye, but the central part will pass through the surface of contact of the prisms and escape the lens. The result will be a dark spot on a bright field (Fig. 4). Hence if both lamps are lighted the center of the field will be illuminated exclusively by the lamp *L* and the rest of the field by the lamp *H*. Then if the lamps are moved until the central spot vanishes, leaving the field of uniform tint, the candle-powers of the lamps are proportional to the squares of their distances from the prisms. (In practice the prisms are placed between the lamps, the light of which is reflected to them by mirrors.) In this apparatus total reflection and total transmission replace the partial reflection and transmission of Bunsen's photometer so that the contrast is sharper and the result more exact. With an improved form, called the contrast photometer, the mean error of measurement is only ¼ per cent, while the mean error of Bunsen's photometer is from 1 to 3 per cent.

In the prism as well as the grease spot photometer the spot does not vanish, even for equal illuminations, unless the lights are of the same color. Many attempts have been made to compare lights of different colors by analyzing them with prisms and comparing their spectra, red with red, yellow with yellow, and so on. This method is not only too laborious for practical use but it fails of accomplishing its avowed purpose



Figs. 2, 3, 4.—LUMMER-BRODHUN PRISM PHOTOMETER.

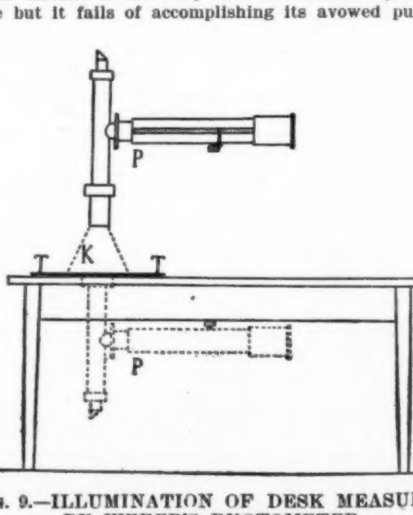


Fig. 9.—ILLUMINATION OF DESK MEASURED BY WEBER'S PHOTOMETER.

for, owing to the essential subjectivity of light and color, the knowledge that one lamp emits twice as much red light, three times as much yellow, etc., as another is not equivalent to a knowledge of their relative total candle-powers, of which the eye alone can judge.

The new method of "flicker" photometry rests upon a sounder basis and has already given excellent results in the comparison of lights of different colors as well as lights of the same color. If a white surface is illuminated alternately, at intervals of 1/16 to 1/10 second, by two sources of light, an appearance of unsteadiness or flickering is produced which vanishes when the intensities of illumination from the two sources become equal. Hence if the surface is moved to a position at which the flickering disappears the relative powers of the sources can be computed from their distances from the surface. The peculiarity of the flicker method is that it is little affected by differences in the color of the lights, for the reason that the eye does not recognize differences in color as quickly as it detects differences in intensity. The difference between the yellowish electric bulb and the greenish Auer burner can be clearly perceived so long as the apparatus rotates slowly, but when the rapidity of alternation is sufficiently increased the alternating yellow and green are replaced by a continuous mixed tint (white) which varies only in brightness. This variation, or flickering, vanishes also when the alternation becomes very rapid, but by selecting a frequency which destroys the difference of tint but not the flickering, the latter may be caused to disappear by moving the lights until they illuminate the surface equally. The relative candle-powers can thus be determined notwithstanding the difference in color. As the comparison is made by the eye the result is probably the true optical intensity, which differs greatly from the photographic and thermal intensities given by such objective instruments as the exposure-meter and bolometer.

No artificial source of light emits rays of equal intensity in all directions. Some radiate more strongly upward, others downward (independently of interception by parts of the lamp) and even the horizontal intensity differs in different directions. The distribution of light by an arc lamp with a clear glass globe is shown in Fig. 5. No light is thrown directly upward and the greatest intensity in any direction in the upper half of the sphere is only 150 HK. The candle-power is about 200 HK in the horizontal plane, below which it increases very rapidly to a maximum of 1,165 HK in a direction about 35 deg. below the horizontal and thence decreases as rapidly to zero at 60 deg. and below.

Which of these values should be taken as the candle-power? For most lamps the horizontal intensity is taken, but for the arc lamp this value, 200 HK, is as clearly too low as the maximum of 1,165 HK, used by some manufacturers, is too high. Better than either is the "spherical" candle-power which is the mean of the intensities in all directions. For the arc lamp described the spherical candle-power is 336 HK.

In general, however, only the light that is thrown more or less downward is of practical importance. Hence another mean value has been suggested, the mean of the intensities in all directions below the horizontal. This is called the "hemispherical" candle-power. In our arc lamp it is nearly twice the spherical power, amounting to 606 HK.

In order to put an end to the confusion caused by the use of these four powers—horizontal, maximum, spherical, and hemispherical—the league of German electrical engineers has adopted the hemispherical candle-power for all measurements of arc lamps. For other lamps the spherical candle-power is generally employed.

The determination of spherical or hemispherical candle-power by summation of intensities in various directions necessitates at least fifteen difficult measurements. Six years ago, however, Ulbricht invented a very simple apparatus and method by which either of these powers can be obtained by a single measurement. The source of light, L (Fig. 6), is placed within a large hollow globe K, the inside of which is painted white. The globe has a small window M covered by opalescent glass and shielded from the direct radiation of the source by a small screen, B. Both theory and experiment prove that the illumination of the window is independent of its position and proportional to the spherical candle-power of the source if this is at the center of the globe, and in practice it is found that the result is not appreciably affected by a considerable eccentricity of the source. Hence the spherical candle-power of the source is determined simply by measuring the brightness of the window M, by means of a photometer, P, and a standard lamp, H, placed beyond it, and multiplying the result by a constant factor determined for the apparatus once for all. To insure accuracy the globe should have a diameter of at least 6 feet. It is usually made of plaster or sheet metal, and in two parts (Fig. 7).

The hemispherical candle-power of a lamp can be measured with the same apparatus by placing the lamp exactly at the center, removing the upper hemisphere and substituting a perfectly black cover of any form. The window is then illuminated only by the lower hemisphere and its brightness is proportional to the hemispherical candle-power.

In many cases the object of inquiry is not the candle-power of a lamp but the degree of illumination at a desk or table. For this purpose special apparatus is used of the type of Weber's photometer (Fig. 8). Two tubes, A and B, are so mounted at right angles that A can rotate in its own plane about the axis of B, the tubes being connected by a short lateral branch of A which enters the mouth of B. The horizontal tube, B, contains an opalescent glass screen, M, which can be moved toward or from the closed end, at which is a little benzine or electric lamp of about ½ HK. One end of the tube A carries a second opalescent screen, N, surmounted by a removable open hood; the other end has an eyepiece O and a total reflection prism, G, for convenience of observation in any position. In this tube, at its intersection with the tube B, is a pair of Lummer-Brodhun prisms (Fig. 4). The inclination of the tube A to the horizon is indicated by the divided circle T.

Weber's photometer can be used for measuring either candle-power or illumination. In the former case the lamp to be measured, L_1, is placed in line with the tube A at a distance r_1 from the screen N. The other screen, M, is then moved until the disappearance of the spot (Figs. 5 and 6) proves that the two screens are equally illuminated. The candle-powers of the lamps are proportional to the squares of their distances from their respective screens; that is, $L_1 = r_1^2/r^2\ L$.

The illumination of a desk is measured by directing the tube A toward a sheet of white cardboard, T, laid on the desk (Fig. 9). The illumination of the screen N is now due to the card and independent of its distance therefrom, provided that the cone of rays defined by the hood does not transcend the limits of the card. Nor need the tube be exactly perpendicular to the card.

FIG. 1.

FIG. 3.

A deviation of 30 deg. is required to cause appreciable error.

It is necessary, however, to standardize the photometer and its card. For this purpose the card is set upright (Fig. 10) and illuminated by a standard Hefner lamp exactly one meter in front of it. The brightness of the card at the point G, opposite the lamp, is the standard of brightness, and is called one "lux." The screen M is moved until the spot vanishes, and its distance r from the inclosed lamp L is noted.

The card is then laid on the desk, the standardized instrument directed toward it as in Fig. 9, the screen N again adjusted to equal brightness with M, and its new distance from the lamp L noted. Then the brightness of the card on the desk is one lux multiplied by r^2/d^2, and this is the measure of the illumination of the desk.

If the shadow of the observer or the instrument interferes with this measurement, the photometer is placed in an inverted position, as indicated by the dotted line (Fig. 9) with the screen in the place formerly occupied by the card, the table and card having been removed. The hood is taken off so that the illumination to be measured falls directly and freely on the screen N. In this case, also, the photometer must be standardized by illuminating the screen N with a Hefner lamp one meter distant from it in the prolongation of the tube A.

By these methods it has been found that the artificial illumination of office and school desks and drawing tables varies from 20 to 100 lux. (For reading, 50 lux are as satisfactory as ordinary daylight, but illuminations less than 10 lux injure the eyes.) The brightest parts of lightest streets at night give results of the same order, while the darkest show only ¼ or ½ lux. Diffused daylight varies from 400 lux on a bright clear day to 2 or 3 lux in cloudy weather. Direct sunlight, with the sun high, equals 60,000 lux according to Michalke and 150,000 lux according to Weber.

These figures strikingly illustrate the enormous differences of lights and degrees of illumination, the great adaptability of the eye, and the immense superiority of sunlight over even the strongest artificial illumination, though this may seem "as bright as day."—Prometheus.

THE PLACE OF ORIGIN OF THE MOON—THE VOLCANIC PROBLEM.*

By PROF. WILLIAM H. PICKERING, Harvard University.

In 1879 Prof. George H. Darwin propounded the view that the moon formerly formed a part of the earth. That it was originally much nearer to the earth than it is at present, and is now slowly receding from us, was clearly shown by his equations. After considerable discussion, his conclusions have been accepted by the great majority of astronomers, although many of the geologists do not view them with favor. Assuming the correctness of his hypothesis, it will be of interest to determine, first, if possible, from what

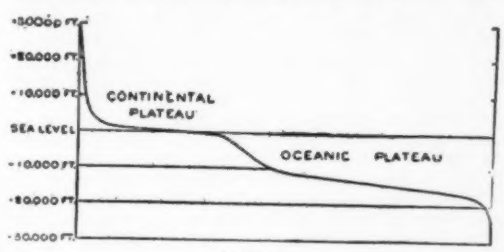


FIG. 2.

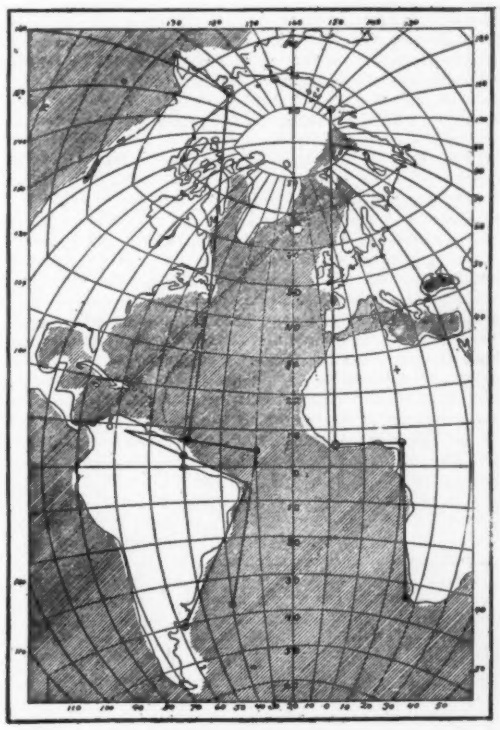


FIG. 4.

part of the earth the moon originated, and, second, to follow out our conclusions on this point and see to what results they may lead.

When the separation took place, it has been shown that the combined planet was not very much larger than is the earth at present. It must therefore have been mostly in the solid or liquid condition. If in the latter state, it is obvious that no indication of the moon's former place could be found at the present time. Very few astronomers or geologists to-day, however, believe that the earth ever was completely liquid. It has probably always been partly solid, partly liquid, and partly gaseous. It is composed of such diverse materials, and these are exposed at different points throughout its volume to such diverse pressures, that, unless we assume it to have condensed from a highly incandescent nebula, which is unlikely, we should scarcely expect it ever to have presented a uniform liquid surface.

The surface was probably hot, but how hot we have no means of knowing. Beneath the surface, however, where radiation was impossible, much higher temperatures were found, as is still the case, and in what follows we shall assume that the interior was practically liquid, or was ready to become actually so where relieved of the pressure due to the gravity of the outer layers; that is, where the centrifugal force became sufficiently high, as in the equatorial regions.

* Popular Astronomy.

Precisely how the earth came into its present form, whether by planetesimal condensation or otherwise, does not concern us here. We merely assume that in these early days the earth was in much the same condition that we find it at present, except that it was hotter. We also assume that it was slowly condensing from a more bulky form, rendering fission possible.

These processes of fission and condensation we see going on all around us at the present time in the stellar universe, as indicated by the variable stars of short period and the spectroscopic binaries. It therefore requires no great stretch of the imagination to conceive that it may also have occurred on a smaller scale in the case of our earth and moon.

It does not follow, however, that our combined planet was ever incandescent. Indeed, this seems to be unlikely. A cold nebula which is later to condense into a sun must almost necessarily be composed largely of solid matter The electric disturbances by which we see it, illumine only the gaseous portions, but the metallic elements must be there nevertheless, all the time unseen.

Assuming then a hot, solid, ellipsoidal earth, with an interior more or less liquid, at least beneath the equator, revolving on its axis once in about four or five hours, we have a picture of our as yet moonless planet as conceived by the astronomer. As it continued to cool, vast volumes of steam and other gases escaped from its interior, increasing its density and diminishing its volume.

As its volume diminished, its speed of rotation increased, until by centrifugal force, as explained by Darwin, the moon was born. If the crust was solid, and if the moon escaped from it, it is almost certain that a scar of some sort would have been left, and it is of interest to see if we can find it.

The specific gravity of the earth as a whole is 5.6. That of the surface material ranges in general between 2.2 and 3.2, with an average of 2.7. The specific gravity of the moon is 3.4. This indicates clearly that the moon is composed of material scraped off from the outer surface of the earth, rather than of matter obtained from a considerable depth. At the same time, the specific gravity 3.4 indicates that the layer of material removed had an appreciable thickness.

As is well known, the land and water are very irregularly distributed over the surface of our globe. If we erect a perpendicular from a point situated one thousand miles to the northeast of New Zealand, and view the earth from a distance in this direction, we shall find that very little land will be visible, while the outline of the Pacific will approach the form of a circle.

Fig. 1 is a map of the globe on zenithal projection, where the radii are proportional to the actual distances represented. There is no distortion, therefore, in the radial direction, and the exact shape of the Pacific with regard to a great circle shown. The inner circle represents the circumference of the globe, and is therefore 90 deg. from the central point. The latitude of this point is 25 deg. S. Away from the center the tangential distances necessarily become more and more distorted, the distortion at the circumference making them appear $\pi/2$ or 1.6 times too large.

Fig. 2 is taken from Gilbert's "Continental Problems of Geology" (Smithsonian Report, 1892), p. 164, and is founded on the results of the "Challenger" expedition as deduced by Murray. In it ordinates represent feet, and abscissas areas, the extreme abscissa representing the total area of the earth's surface. This area is composed chiefly of two plateaus: one the continental, whose mean altitude is 1,000 feet above sea-level, the other the oceanic, whose mean altitude is —14,000 feet.

It will be noticed that the edge of the continental plateau is below sea-level, but not more than 1,000 feet below it. This contour may be taken, therefore, as the true boundary more properly than the waterline itself. In Fig. 1 it is indicated by a dotted line. Its position near the Antarctic continent is unknown. The location of the latter, excepting where indicated by the full line, has not been determined. The line composed of dashes therefore indicates its maximum possible area.

If we travel north 90 deg. from the central point of Fig. 1, to the immediate vicinity of Bering Strait, and erect another perpendicular, from which we again examine the globe, we shall obtain a view resembling Fig. 3. In this map, which is drawn in orthographic projection, there is no tangential distortion, and the appearance is that which the earth would have if seen from a great distance. The vertical line is a meridian; the horizontal is a projection of the inner circle shown in Fig. 1. The continents and islands at the edges of the disk have been allowed to project out beyond the ocean beds in order to make more evident the systematic grouping of the continental masses on one side of the globe. With the exception of Australia, the Antarctic continent, and a small part of South America, all represented in the lower half of Fig. 1, there is no important land on the water side of the globe, not shown in Fig. 3.

An inspection of this figure shows that the earth's center of gravity, which is the center of the circular arcs, does not coincide with its center of volume, and this deviation would be still more marked were the mobile portions of the surface—i. e., the oceans—drawn off. The center of gravity would then be slightly raised in the figure, and the center of volume still more so. The ocean side of the solid earth has obviously a higher specific gravity than the continental side.

It is the general opinion among geologists that the continental forms have always existed—that they are indestructible. How then, could they have originated? We know something of the permanent surface features of three bodies in the universe besides the earth; namely, the moon, Mars, and Mercury. None of these shows us anything resembling the irregular terrestrial distribution of the high- and low-level plains, of our continents and oceans.

If we examine more minutely the coasts of our great oceans, we shall find the Pacific bounded by a nearly continuous line of active or extinct volcanoes, and this is true whether in North or South America, Asia, the East Indies, New Zealand, or Antarctica. The only possible break is the east coast of Australia, but even here there is a line of volcanic islands, lying a short distance off the coast, stretching from New Guinea more than half-way to New Zealand. The coasts of the Pacific are generally mountainous and abrupt, and composed of curves convex toward the ocean.

The Atlantic coasts, on the other hand, are generally low, flat, and composed of curves as often concave as convex. As to volcanoes, they are few and scattering. The only conspicuous exception to the general rule is the range of the Lesser Antilles, which both in form and volcanic nature reminds us of the Pacific coast of Asia. The Indian Ocean resembles the Atlantic, except where it approaches the vicinity of the Pacific, and there the characteristic volcanoes again appear.

A curious feature of the Atlantic Ocean is that the two sides have in places a strong similarity. Fig. 4 is drawn in globular projection, which is used so frequently for the hemispheres in ordinary atlases, except that in this instance the projection is carried over the pole onto the other side. This projection gives very little distortion in the vicinity of the central meridian, which is the portion of the map to which we shall especially refer. The shaded areas represent those parts of the ocean that are more than 1,000 feet in depth. Regarding the unshaded area between America and Asia we have no information.

When the earth-moon planet condensed from the original nebula, its denser materials collected at the lower levels, while the lighter ones were distributed with considerable uniformity over its surface. At the present day we find the lighter materials missing from one hemisphere. The mean surface density of the continents is about 2.7. Their mean density is certainly greater. We find a large mass of material now up in the sky, which it is generally believed by astronomers formerly formed part of our earth, and the density of this material, after some compression by its own gravity, we find to be 3.4, or not far from that of the missing continents. From this we conclude that this mass of material formerly covered that part of the earth where the continents are lacking, and which is now occupied by the Pacific Ocean. In fact there is no other place from which it could have come.

Who it was that first suggested that the moon originated in the Pacific is unknown. The idea seems to be a very old one. The object of the present paper is to find what support for this hypothesis is afforded by the results of modern science, when examined both qualitatively and quantitatively.

The volume of the moon is equivalent to a solid whose surface is equal to that of all our terrestrial oceans, and whose depth is thirty-six miles. It seems probable, therefore, that at this time the earth had a solid crust averaging thirty-six miles in thickness, beneath which the temperature was so high that the materials were in places liquid, and in other places only kept solid by the enormous pressure of the superincumbent material. When the moon separated from us, three-quarters of this crust was carried away, and it is suggested that the remainder was torn into to form the eastern and western continents. These then floated on the liquid surface like two large ice-floes.

If their specific gravity was the same as that of the moon, 3.4, since the continental plateau averages nearly three miles higher than the ocean bed, the specific gravity of the liquid in which they floated must have been 3.7. Later, when this liquid surface cooled, the huge depression thus formed was occupied by our present oceans.

The volcanic islands in the oceans, such as Hawaii, were obviously formed after the withdrawal of the moon, and are analogous to the small craters scattered over the lunar *maria*. While their surface material presents no extraordinary density, the lava being full of bubbles and small cavities, interesting results have been obtained by the Coast Survey with the pendulum. Observations were made by E. D. Preston near the summit, and on the slopes of Mauna Kea, Hawaii, at altitudes of 13,060, 6,660, and 8 feet. He writes:

"It appears that the lower half of Mauna Kea is of a very much greater density than the upper. The former gives a value of 3.7, and the latter 2.1, the mean density of the whole mountain being 2.9. This is somewhat greater than that found for Haleakala (a neighboring volcano) and is notably larger than the density of the surface rocks. Indeed, this appears to be the highest value yet deduced from pendulum work."*

The remark of Major Dutton† is interesting in this connection, that a part of the bulk of these mountains is due to accumulation, and a part to uplifting. The upper half is clearly due to matter, chiefly scoria, which has been expelled from the various vents. The lower half is probably due to the slow uplifting of the former ocean bed.

It would seem as if borings carried on in this vicinity to a depth of only a few hundred feet would bring to the surface the same kind of rock material that, beneath the continents, would only be found at a depth of many miles. Presumably this material would turn out to be lava similar to that found on the surface, save that under the great pressure the innumerable little cavities, rendering the material generally so porous, would have practically disappeared. The fact that its density, 3.7, as determined by Preston, coincides with the theoretical value just deduced is of interest.

Turning now to Fig. 4, six points indicated by circles have been marked along the coast-line of the eastern continent. Corresponding to these, six similar points have been marked along the American coast. The two broken lines joining these various points are slightly inclined to one another, but the other small differences in relative position and distance are apparent and not real, being due to the necessary slight distortion of the map. The South American continent does not fit well into this arrangement, and does not appear to have remained perfectly parallel to North America during its transit across the fiery ocean, in obedience to the pull of the moon. Instead, it seems to have rotated slightly, as shown, about a point somewhat to the east of the Isthmus of Panama.

In trying thus to match the continents together, we must take the outline of the continental plateau rather than the coast line. Five-sixths of the area of the Atlantic basin is thus very well accounted for, but there still remains a considerable area east of the United States, together with the Gulf of Mexico, and the Caribbean and Mediterranean Seas, not explained. The eastern outline of the Atlantic area is indicated by the dotted line.

The antipodes of the central spot in the map of the Pacific is indicated by the cross in northern Africa. If the ultimate releasing force which caused the disruption of the moon was, as has been supposed, the solar tides, we should expect that a certain amount of material might escape from both sides of the earth. If the sun were overhead at the central point in the Pacific, then within less than an hour, using Darwin's rate of rotation, it would have been exactly opposite to the area in question in the Atlantic, Gulf, and Caribbean Sea.

The similarity of the Lesser Antilles to the Asiatic islands, already pointed out, corroborates this explanation. It is also to be noted that the greatest depths in the Atlantic, 21,000 feet, are found along the eastern boundary of this region. Similarly, one of the deepest parts of the Pacific, 31,000 feet, is indicated by the × close to the central point on the map, Fig. 1. Around this deep portion on the east, north, and west is a shallower area from 15,000 to 20,000 feet in depth, and then, as we approach the continents, again a deeper area.

All those who have studied the stratification of the Appalachian region have concluded that the sediments came chiefly from the east. Such extensive deposits require a larger land area than now exists; in fact, one is needed of continental proportions. Whether these deposits are sufficiently ancient to be explained by the lunar hypothesis the writer is not prepared to say.

There are several coincidences relating to the position of the central point of the Pacific which may or may not be accidental. The close coincidence with the very deep area above noted is the first of these. The second relates to its latitude, —25 deg. This is within a degree and a half of the tropic of Capricorn. The tropics are the lines on a uniform sphere where the direct solar tidal pull acts for the greatest length of time on any particular area of rock. Here also the leverage of the tidal pull on the earth's crust would be greatest in displacing a protuberant equatorial ring. If the moon were generated from the earth by centrifugal force, liberated by the tides, we should expect the central point to coincide with one of the tropics of that time. The coincidence with the present tropic would indicate that the axis of the earth can have changed very little in the meantime. The third and fourth coincidences are more likely to be accidental. The third is that the central point coincides in longitude with Bering Strait, where the two continents are supposed to have slipped past one another. The fourth is that the strait is almost exactly 90 deg., more accurate 91 deg., in latitude from the central point.

If the greater continents were split apart, we should by the same analogy conclude that Antarctica and Australia were drawn from the Indian Ocean; the former from the vicinity of the Cape of Good Hope, the latter farther east.

If it is true, as here suggested, that we owe our continents to the moon, then the human race owes far more to that body than we have ever before placed to its credit. If the moon had not been formed, or if it had carried away the whole of the terrestrial crust, our earth would have been completely enveloped by its oceans, as is presumably the case with Venus at present, and our race could hardly have advanced much beyond the intelligence of the present deep sea fish. If the moon had been of but half its present bulk or had been slightly larger than it is at present, our continents would have been greatly diminished in area, and our numbers decimated, or our lands over-populated.

Connected intimately with the origin of the continents is the problem as to the cause of volcanoes, and why they are at present always situated near the sea. A point that is of the utmost consequence in its bearing on this question is the fact, noted by Charles

* American Journal of Science, vol. cxlv (1893), p. 256.

† United States Geological Report, 1882-83, p. 195.

Darwin, that active volcanoes are found only where the coast-line is rising. Clearly the same cause produces both effects.

A rising region, as pointed out by Dutton, must evidently be increasing its volume. This increase may occur either with or without an increase of mass. In the latter case the increase must be due to a rise of temperature. It has been shown that, if a part of the earth's crust fifty miles in thickness were to have its temperature raised 200 deg. F., its surface would be raised to the extent of 1,000 to 1,500 feet.* The Bolivian plateau has an elevation of two and a half miles. That of the Himalayas is about a mile higher. It is improbable that these elevations are due to this cause.

The alternative is that in the rising regions we have an increase of mass. If the mass were increased materially, it has been shown by Gilbert† that the hot subterranean region should yield to the added pressure, thus neutralizing the elevation. An added column of rock two miles in height could not possibly be supported. Apparently our last resort is to introduce some lighter material, such as water or steam. The pressure on the steam, if its temperature were above the critical point, would be so great that its density would be but little less than the equivalent extrapolated value for water. It might have one-fourth of the weight of an equal column of rock.

Liquid lava is full of water, and as the lava cools the water is expelled from it. The lava at Hilo, Hawaii, contains innumerable bubbles, indicating the presence of steam, which had been retained by it within its structure for many days, ever since it had left the crater of Mauna Loa, fifty miles distant.

Since volcanoes are intermittent in action, the charging process must still be going on at the present time; otherwise there would have been one long discharge in the distant past, which would have rendered all our present volcanoes extinct.

Since volcanoes are active only near the oceans, it has been suggested that the eruption is due to sea water that has entered by cracks in the earth's crust and is subsequently discharged from the volcano. Volcanoes do discharge salt water, but the solid ingredients of the water do not occur in the same proportions that they do in the sea. Some of the sea salts are often found to be absent, while other salts are often found that do not occur at all in sea water. This fact together with the inherent improbability that sea water should be sucked in at a low level and pumped out at a high one, renders this explanation improbable.

Another explanation of the universal presence of water in volcanic products is that it is derived from rain water, which has percolated down through the soil. This theory, however, does not account for the fact that volcanoes are always found near the sea. Neither of these theories accounts for the gradual elevation of the land in volcanic regions.

Since the process of charging volcanoes with steam is still going on, and since it appears that the necessary water is not derived from either the sea or the atmosphere, the only alternative seems to be that it comes from the heavy stony material forming the ocean beds, and does not come in appreciable quantities, at present, from the lighter material forming the continents. It is evident, however, that this lighter material is sometimes cracked, permitting the discharge to take place through it. This was the case with the extinct volcanoes in central Europe, and those near the Yellowstone Park and Arizona in this country. The volcanoes at present active in North and South America seem to rise from what was probably formerly the edge of the continental plateau.

The next question that arises is: From what depth does the lava come? Judged by its temperature at the vent, unless it becomes heated by friction, by compression, or by radio-activity, on its way to the surface, which seems improbable, it must have come from a considerable distance. The rate of increase of temperature with the depth varies in different parts of the world from 20 to 100 feet per deg. F. It may fairly be taken near the surface at 100 deg. per mile of depth. From its surface temperature, Bonney estimatest that "lava is generally supplied from a zone situated at a depth of from 20 to 25, or possibly to 30 miles, in the crust of the earth." The total thickness of the crust has been estimated by Fisher§ at 30 miles. These values agree very well with that just computed from the volume of the moon.

Daubrée has shown‖ that water separated from a chamber filled with steam at a temperature of about 160 deg. C. by a close, fine-grained sandstone, passed through the slab with ease, against the outward pressure of the steam. He also found that the facility with which the water found a passage was increased by heat. There is therefore no difficulty in understanding the transmission of water through hot rocks at considerable depths. Its presence, moreover, would tend to lower the melting-point of the rock, and make it more viscous.

A certain amount of water may even be transmitted in this manner down through the ocean floors; but when we consider that the transmitting medium consists of cold rock several miles in thickness, the water advancing against a constantly increasing pressure, it does not seem that the amount transmitted per year in this manner can be very large.

In our hypothesis explaining the origin of the continents, it was stated that they were composed of the crust which was either originally solid or else had already cooled sufficiently to become so. They had therefore expelled a large part of any water which they may originally have contained. The ocean beds at the time of the great catastrophe were liquid. They therefore absorbed all the water available, if indeed they were not already saturated with it. They had a much higher temperature, having come from a greater depth, and contained much more water at this period, than the continents, and, it is believed, have been giving it out as they cooled ever since.

Doubtless the hot bases of the continents have absorbed some water from the ocean beds as the latter cooled, and the expansion and diminished specific gravity thus caused would tend to elevate them in the vicinity of the oceans. This has occurred notably in the vicinity of the Pacific, the whole of whose coasts are at the present time in a state of elevation. We can understand also that the systematic difference in material and density, extending over large areas, would render the boundaries of the continents more subject to cracks, with their resulting volcanoes and earthquakes, than other portions of the earth's surface. A zone of territory subject to earthquakes extends around the Pacific.

As is known from its rigidity, the interior of the earth as a whole is solid. There cannot even be at present a continuous liquid surface between the center and the crust. Beneath every active volcano, however, there must be an area from which its lava is derived. In some way, without doubt by the contraction of the earth, this lava is caused to approach the surface, and on the way it gradually changes from a viscous solid to a viscous liquid. There are only two ways in which this change can take place: one is by an increase in temperature, the other by a decrease in pressure. The latter is probably the actual one.

Tangentially considered, the lower portions of what we may for convenience call the earth's crust are in a state of compression, the upper portions in a state of tension. Radially all are in a state of compression. Between the upper and lower portions is a neutral surface of no tangential strain. When a crack caused by the tangential tension reaches this neutral surface, the viscous rock oozes up through it, becoming more and more liquid as it approaches the surface and the pressure is diminished. As it melts and is relieved of pressure, its density diminishes, and, if it finally reaches the surface, the erupted lava will continue to flow till the pressure at its source is reduced to equality with the hydrostatic pressure at the base of the crack. The larger the opening and the shorter the distance from the surface, the sooner will this equality of pressure occur, and the shorter be the duration of the eruption. The expansion of the bubbles of steam near the top of the crack diminishes the hydrostatic pressure, and their escape obviously causes the explosions usually noticed. The violent manifestations are therefore all generated near the surface, as is the case of a geyser.

The uprush and escape of all this material broaden the crack into a tube several hundred feet in diameter. After the lava has ceased to flow, the steam working its way up to the vent still keeps a somewhat narrowed passage open. It thus continues as a line of weakness; and when the flow of steam and viscous rock from below on all sides toward the area of diminished pressure again increases this pressure beyond the breaking strength of the resisting material, the eruption will be renewed.

Volcanoes frequently lie along arcs of circles, which if complete, would resemble the lunar *maria* both in size and shape. One of the most complete of these series of arcs has the China Sea for its center, while the volcanoes are found in the Philippines, Celebes, Java, Sumatra, the Malay peninsula, and southern China to the west of Canton. The diameter of this circle is 2,000 miles. The Japan and Bering seas are similarly partly surrounded by incomplete arcs. The shape of the latter is decidedly elliptical.

* Judd, Volcanoes, p. 347.
† Continental Problems of Geology, Smithsonian Report, 1892, p. 165.
‡ Volcanoes, p. 284.
§ Milne, Seismology, p. 120.
‖ Geological Experiments, vol. i, p. 278.

Dr. C. W. Andrews has recently described to the Geological Society a cervical vertebra, found in the Barton Clay of Barton Cliff, which has been referred provisionally to *Zeuglodon Wanklyni*, a species described in 1876 by Prof. H. G. Seeley. The skull on which this description was founded is totally lost, so that this vertebra is the only bone of a *Zeuglodon* from the Barton Clay, and, with the possible exception of a vertebra from the Brockenhurst Beds (which is the type of *Balænoptera Juddi*), the only one found in the British Isles that now exists. In commenting on the discovery, Prof. Seeley remarked that no figure was given of his drawing of the parieto-frontal region in *Zeuglodon Wanklyni*, and he therefore drew attention to the circumstance that it was much broader and more convex on the upper aspect than in any Zeuglodonts subsequently made known from newer beds, and might possibly be referable to a distinct genus on this evidence. The caudal vertebra which he had described as *Balænoptera Juddi* he had long since chronicled as the caudal vertebra of a *Zeuglodon*, possibly identical with the Barton species. He referred also to the fact that in the Sedgwick Museum are similar caudal vertebræ of a Zeuglodont, which he believed were obtained by Mr. Henry Keeping, from an excavation at Brockenhurst in the Brockenhurst Beds. Dr. Smith Woodward understood that the vertebra now found was obtained from a local collector, who had sold some associated vertebræ to casual visitors to Barton. He hoped that the publication of the paper would lead to the recovery of these specimens for scientific examination. Geologists will perhaps note.

SCIENCE NOTES.

Mr. H. Cunynghame has devised a detached gravity escapement. The object of this escapement is to cause the impulse on the pendulum to be given by means of a light arm which falls by the action of gravity, and is hence independent of the force of the train, and to provide that the release of the train that winds up the arm is not derived from a blow by the pendulum, but of the arm itself, so that both the impulse given to and taken from the pendulum shall be exactly at the center of the swing, and independent of the force driving the train.

Dr. J. R. Milne has invented a special camera for the purpose of automatically recording the readings of the scale of any instrument. The purpose of this invention is to enable one, when using any piece of physical apparatus, which has a scale and vernier, to record whenever wished the readings of the latter. The observer effects this by simply pressing a bulb, which causes the camera to make a photograph of the scale and vernier on a small portion of its sensitive plate. The plate is then automatically moved on a step so as to present a fresh surface for the succeeding photograph. The plates employed can each receive seventy records.

Interesting relics of archeological value have recently been unearthed in different parts of Britain. During the excavation of some sandpits at Crayford in Kent, a number of metal articles were found about four feet below the surface. Upon examination they were ascertained to be fashioned in solid gold, of massive and heavy design, and of very early origin. They were evidently amulets, for although they were oval in shape, spaces were left for the insertion of the ankle or arm. Judging from the size of the ornaments and the orifices, they were apparently articles of feminine adornment. The intrinsic value of the metal is approximately $1,500, but from antique and historical points of view their value is almost priceless. The relics are in a perfect state of preservation, and are inscribed with hieroglyphics which have not yet been deciphered. The period to which they belong is computed to be far before the Christian era. It is believed that the spot at which they were discovered constituted a burial place of the ancient Britons, who were interred with their implements of war and personal embellishments. This contention is substantiated by the fact that at the same place on several previous occasions various other articles of an early date, consisting of flint and stone weapons, human bones, and so forth, have been brought to light. The previous discoveries now repose in the British Museum, to which the present articles will doubtless be presented, since they are the property of the crown. At Manchester interesting relics pointing to the extent and period of the Roman occupation of the city have been brought to light. In the course of excavations on the site of the Roman fort within the civic boundaries a number of coins, none of which were struck before 117 A. D. or after 176 A. D., were found. One rare bronze coin of Antoninus was certainly not struck after 145 A. D. It is conjectured from the results of the investigations upon this site that the buildings were reconstructed either before or during the reign of Hadrian, and that a portion of the re-erected buildings were in some way destroyed by fire, probably by the marauding brigands about the time of Marcus Aurelius.

Not long since we had occasion to speak of a curious property of platinum amalgam discovered by M. Moissan. When shaken up in water it forms a semi-solid mass resembling butter in consistence and having five or six times the original volume of the amalgam. M. Lebeau, of Paris, has made a further study of this phenomenon. He finds that platinum is the only metal which has this property. The quantity of platinum which the amalgam contains in order to make an emulsion may be small. An amalgam with two per cent platinum is already of a pasty nature, but it is fluid enough to give a good emulsion. A 0.57 per cent amalgam will increase five times its initial volume. If we add a volume of water below what is needed, the water disappears entirely. Lowering gradually the percentage of platinum we still observe a swelling for an amalgam of 0.038 per cent. But the emulsions made with water and an amalgam below 0.1 per cent platinum are not very stable and the mercury separates after a time. The volume of the emulsion depends, as M. Moissan found, upon the nature of the liquid. We could also vary the volume by mixing other amalgams with the platinum amalgam. Mixing a 0.57 per cent amalgam with the same volume of a zinc or tin amalgam caused it to lose the property of forming an emulsion. Modifying the state of the platinum also changes the results, and an amalgam prepared with platinum sponge finely divided and obtained at as low a temperature as possible, will give very voluminous emulsions. With a strongly calcined platinum sponge, this property is lowered considerably. Using an amalgam prepared with platinum filings, no emulsion is produced with water or other liquids and the amalgam acts like pure mercury. The author wished to make a microscopic examination of the substance and so used a 0.57 per cent amalgam, shaking it for fifteen seconds with a gelatine solution and obtained an emulsion as with pure water. When the gelatine is hardened and the whole is cooled below the freezing point of mercury, a section can be made which is not further changed at the ordinary temperature and which can be photographed. Such photographs resemble sections of vegetable cellular structures, and can also be compared to

that of soapsuds in which the gases are replaced by liquids. No chemical action is found in the above phenomena, and the formation of the emulsion seems to be due to surface tensions which are exercised between the liquid and the amalgam.

TRADE NOTES AND FORMULÆ.

Varnish for Violins.—To 21 parts of 90 per cent alcohol add 160 parts of sandarac gum, 80 parts of mastic gum, and 750 parts of turpentine varnish in a tin can. Set it on the stove, keep it well agitated until completely melted, and strain it.

Violin Varnish (according to F. Alpers).—Genuine Canada balsam is dissolved warm in 96 per cent alcohol, rectified spirits of lavender, or rectified spirits of turpentine, so that a perfectly clear fluid is obtained, and to this add balsam solution, according to circumstances, a small percentage of freshly selected mastic, some clear, unbleached shellac solution, and a few drops of old linseed oil.

Plastic Mass for Picture Frames.—13 parts of white glue, 4 parts of litharge rubbed to an impalpable powder, 8 parts of white lead, 1 part of fine sawdust, and 10 parts plaster of Paris. The glue, previously thoroughly softened in water, is dissolved in water, which is poured into the litharge, the other substances being incorporated in the mixture in their order. The finished mass is poured into separable molds previously slightly oiled, the second part of the mold adjusted, and the work taken out when thoroughly hard.

Flavoring Extracts.—Aromatic: 500 parts of curaçao shells (orange peels); 50 parts cascarilla bark; 200 parts cinnamon bark; 50 parts cardamoms; 25 parts cubebs; 150 parts of cloves; gentian root, 100 parts. Digest for eight days with 4,000 parts of 80 per cent alcohol, mix with 4,000 parts of 80 per cent alcohol, and 12,000 parts of sugar solution.

Aromatic: Cinnamon liqueur, 22,000 parts; clove liqueur, 10,000 parts; ginger liqueur, 8,000 parts; curaçao, double, 8,000 parts; peppermint, double, 1,000, and Jamaica rum, 1,000 parts.

Aromatic Essence: Cassia, 1,000 parts by weight; Malabar cardamoms, 3,000 parts; cloves, 300 parts; galangal root, 300 parts; ginger, 400 parts; orange peel, 200 parts, digested for 8 days with 10,000 parts of 50 per cent alcohol, pressed out, and filtered. To this add Ceylon cinnamon oil, 30 parts; oil of mace, 75 parts; dissolved in 1,000 parts of 95 per cent alcohol. As a liqueur, to 38 parts of 95 per cent alcohol add 4 to 5 parts of the above essence and 10 parts of sugar, to which enough water has been added to make up 100 parts. Color cinnamon brown with burnt sugar.

Aromatic Essence: Liqueur, 20 parts by weight; curled-mint oil, 10 parts; oil of lavender, 15 parts; oil of mace, 15 parts; oil of bitter almonds, 12 parts; oil of balm, 100 parts; essence of musk, 10 parts; oil of orange flowers (neroli), 80 parts; oil of calamus, 80 parts; oil of lemon, 30 parts; oil of cloves, 30 parts; oil of cassia, 100 parts; essence of violets, 150 parts; peach ether, 150 parts; alcohol, 5,348 parts; uncolored.

Aromatic Essence: *a.* Cardamoms, 83 parts, by weight; clove spice, 166 parts; mace, 166 parts; cinnamon, 580 parts; alcohol, 10,000 parts. *b.* Curaçao shells (orange peel), 416 parts; clove spice, 83 parts; mace, 83 parts; alcohol, 10,000 parts. *c.* Angelica root, 120 parts; calamus root, 120 parts; camomiles, 100 parts; galangal root, 120 parts; ginger root, 10 parts; bayberries, 120 parts; mace, 20 parts; clove spice, 60 parts; orange peel, 80,000 parts; peppermint, 160 parts; cinnamon, 100 parts; wild vine root, 200 parts; alcohol, 10,000 parts. *d.* Orange peel, skinned (white flesh cut off), 450 parts; clove spice, 90 parts; mace, 90 parts; alcohol, 10,000 parts. *e.* Angelica root, 100 parts; calamus root, 100 parts; cardamoms, 100 parts; Peruvian bark, 50 parts; ginger root, 50 parts; lavender herb, 200 parts; mace, 15 parts; nutmeg, 25 parts; orange peel, 300 parts; peppermint (herb), 200 parts; cinnamon, 50 parts; cinnamon root, 100 parts; alcohol, 10,000 parts.

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TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Aerial Locomotion.—III.—By ALEXANDER GRAHAM BELL.—10 illustrations.... 26269

II. AGRICULTURE.—Artificial Fertilisers: Their Nature and Function.—By A. D. HALL.—1 illustration.... 26273

III. CRYSTALLOGRAPHY.—The Birth and Affinities of Crystals.. 26272

IV. ELECTRICITY.—The Operation of Mechanical Devices at a Distance by Means of the Wireless Transmission of Energy.—By Dr. ALFRED GRADENWITZ.—9 illustrations.... 26276

V. ENGINEERING.—The Enrichment of Liquid Fuels.... 26274
The Sanitary Engineering Problems of Water Supply and Sewage Disposal in New York City.—By GEORGE A. SOPER.... 26275

VI. GEOLOGY.—The Place of Origin of the Moon—The Volcanic Problem.—By Prof. WILLIAM H. PICKERING.—4 illustrations. 26281

VII. MISCELLANEOUS.—The Saunders System of Sewn Boats.... 26272
Sir J. Crichton Browne on Ambidexterity.... 26279
Science Notes.... 26283
Trade Notes and Formulæ.... 26284

VIII. OPTICS.—Remarkable Eyes of Primitive Peoples.... 26279

IX. PHOTOMETRY.—Modern Methods of Photometry.—By VICTOR QUITTNER.—9 illustrations.... 26280

X. TECHNOLOGY.—Recent Improvements in Machinery for Drying Different Products.—By S. E. WORRELL.... 26271
Artificial Fireproof Stones.... 26277
The Varied Uses of Cypress.... 26279